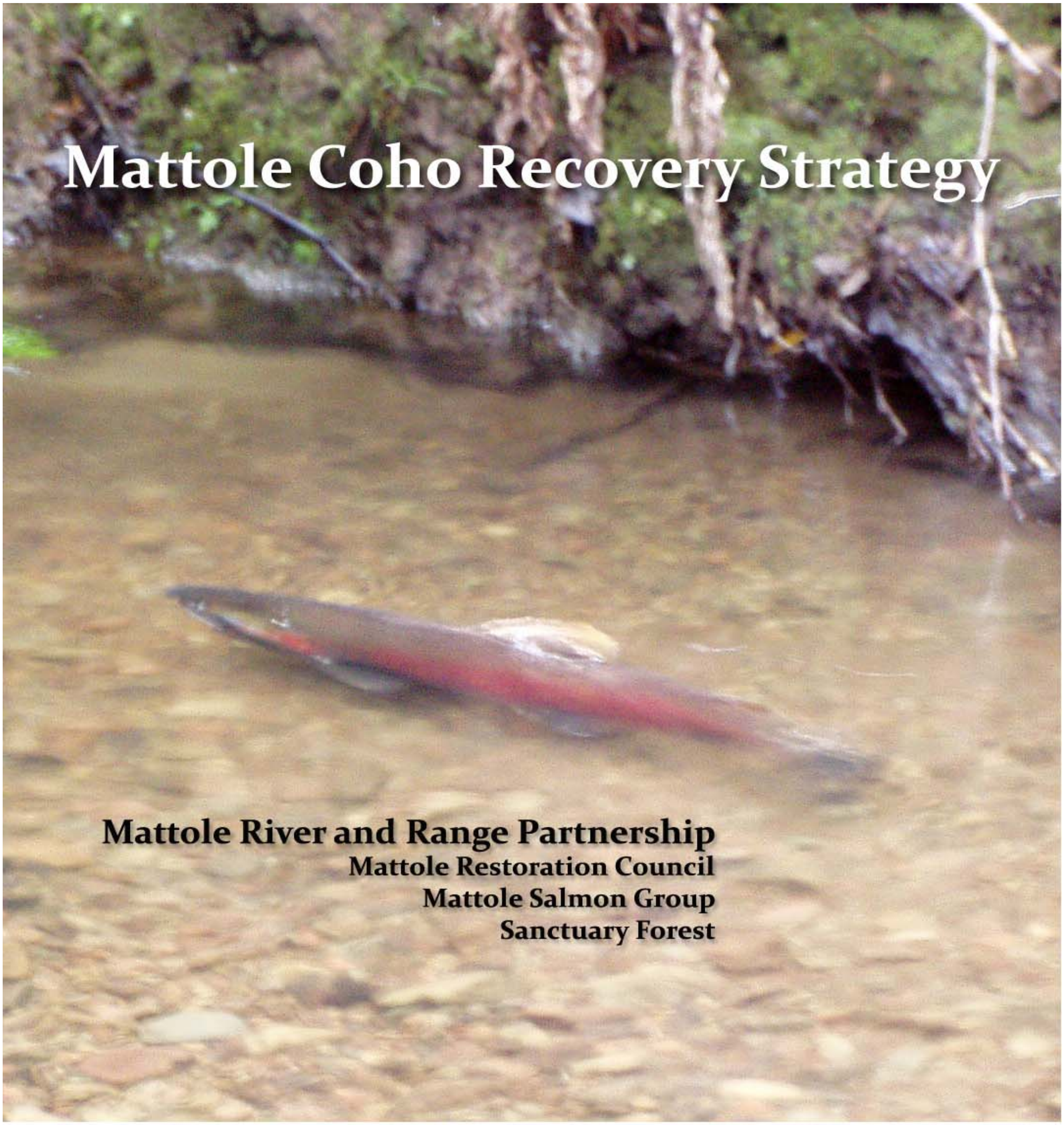


Mattole Coho Recovery Strategy

Mattole River and Range Partnership
Mattole Restoration Council
Mattole Salmon Group
Sanctuary Forest

January 2011

Mattole River and Range Partnership
Mattole Coho Recovery Strategy

Produced by:
Mattole Restoration Council
Mattole Salmon Group
Sanctuary Forest

Funded by:
State Water Resources Control Board
Conservation Lands Foundation

Special thanks to:
Mattole Salmon Group: Keytra Meyer, Amy Baier, Kate Cenci, Matt Hanington, Campbell Thompson, Sarah Burstein, and Amanda Piscitelli

Mattole Restoration Council: Nathan Queener, Stephanie Cepellos, Gary "Fish" Peterson, Seth Zuckerman, Hugh McGee, Joel Monschke

Sanctuary Forest: Tasha McKee, Noah Levy

Technical expertise, contribution, and review: Frank Ligon (Stillwater Sciences), Maureen Roche (Mattole landowner and Mattole Salmon Group volunteer), Ray Lingel (Mattole Salmon Group Board of Directors), Dave Fuller (BLM), Hart Welsh (Redwood Sciences Lab and Mattole landowner), Richard Gienger (Mattole Restorationist), Bob Pagliuco (NOAA Fisheries), Michelle Gilroy (CDFG), and Stillwater Sciences.

Maps produced by:
Mattole Restoration Council GIS

Photo on front cover:
Coho salmon (*Oncorhynchus kisutch*) in the Mattole River Watershed. Photo courtesy of Campbell Thompson, Mattole Salmon Group.

Document citation:
Mattole River and Range Partnership. 2011. Mattole Coho Recovery Strategy. Petrolia, California.

Mattole River and Range Partnership
Mattole Coho Recovery Strategy

Table of Contents

List of Figures

List of Tables

List of Acronyms and Abbreviations

AREMP: Aquatic and Riparian Effectiveness Monitoring Program
BLM: Bureau of Land Management
˚C: Celsius or Centigrade
CCC: Central California Coast
CDFG: California Department of Fish and Game (also DFG)
cfs: cubic feet per second, a unit of streamflow
CHA: Coastal Headwaters Association
DFG: California Department of Fish and Game (also CDFG)
DIDSON™: sonar instrumentation that can be used to estimate adult salmonid escapement
DO: dissolved oxygen
DPS: Distinct Population Segment
DS: downstream
DSMT: Downstream Migrant Trap
EI: Escapement Index (average number of redds observed per accumulated survey mile)
EPA: Environmental Protection Agency
ESU: Evolutionarily Significant Unit
˚F: Fahrenheit
FL: Fork Length
FR: Federal Register
FRGP: Fisheries Restoration Grant Program
ft, ′: feet, ft^2: square feet, ft^3: cubic feet
ft/s: feet per second
GIS: Geographic Information System
GRCC: Good Roads, Clear Creeks (an MRC program focused on reducing sedimentation from roads)
IP: Intrinsic Potential
km, KM: kilometer
LWD: large woody debris
m: meter
MCRS: Mattole Coho Recovery Strategy
mg/L: milligrams per liter
MICWMP: Mattole Integrated Coastal Watershed Management Plan
mm: millimeters
MRC: Mattole Restoration Council
MRRP: Mattole River and Range Partnership
MS: mainstem
MSG: Mattole Salmon Group
MWAT: Maximum Weekly Average Temperature
MWMT: Maximum Weekly Maximum Temperature
N/A: Not Applicable or Not Available (also n/a)
NCWAP: North Coast Watershed Assessment Program
NMFS: National Marine Fisheries Service (now called NOAA Fisheries)
NOAA: National Oceanic and Atmospheric Administration
NTU: Nephelometric Turbidity Units
pers. comm.: personal communication

PIT: Passive Integrated Transponder

PDO: Pacific Decadal Oscillation

PLD: Peak Live plus cumulative Dead (method for estimating adult salmonid escapement)

RER: Riparian Ecosystem Restoration (MRC program focused on restoring riparian areas)

RM: River Mile of the mainstem Mattole River, defined as the number of miles upstream from the mouth of the Mattole along the river's mainstem. A '+' designation is used when referring to a Mattole tributary and the distance above the tributary's confluence (e.g., “Thompson Creek RM 58.4+0.13” means that Thompson Creek joins the Mattole at RM 58.4, and refers to a location 0.13 miles upstream from its mouth)

SFI: Sanctuary Forest, Inc.

SONCC: Southern Oregon Northern California Coast

SPP: Smolt Production Potential

SWRCB: State Water Resources Control Board

TRT: Technical Recovery Team

UC: University of California

UMRFC: Upper Mattole River and Forest Cooperative

US: Upstream

USFWS: U.S. Fish and Wildlife Service

USGS: U.S. Geological Survey

VSP: Viable Salmonid Population

YOY: young of the year salmonids, or fry

I. Introduction

A. Purpose and Need

Coho salmon are acknowledged to be the most imperiled of the Mattole River's three native salmonid species: Chinook salmon, coho salmon, and steelhead trout. While Mattole restorationists have a general idea of the factors which are most limiting to the survival of the population, a more detailed understanding of coho survival and growth by life stage and spatial use of habitat throughout the watershed is necessary to target restoration efforts most efficiently. There is a pressing need to identify specific recovery actions, and prioritize and implement those actions which will be most likely to increase the viability of the population. The extremely low numbers of returning adults the past few spawner seasons underscore the importance of using all of the information at our disposal to make informed decisions about project implementation.

As in most watersheds, our information on historic and current coho salmon distribution is incomplete and imperfect. We must take into account anecdotal information and inference to arrive at the best possible understanding of coho abundance and distribution in the watershed. This document addresses the following objectives:

- Use historical information and models of habitat potential to increase our understanding of potential coho distribution in the watershed and habitat conditions.
- Analyze existing juvenile, smolt, and adult distribution and abundance data to obtain more precise population estimates and develop hypotheses about the most important sources of mortality by life stage.
- Determine gaps in data and specify monitoring actions to address those gaps.
- Determine risk of extinction and current population abundance and distribution, based on current and historical population estimates.
- Determine where recovery efforts should be focused based on historical distribution and abundance and present distribution and habitat conditions.
- Determine recovery actions for specific tributaries and stream reaches based on findings of limiting factors per life stage.

B. Relationship to Previous Documents

The Mattole Coho Recovery Strategy (MCRS) is directly related to two recently completed planning documents. The *Mattole Integrated Coastal Watershed Management Plan, Foresight 2020* (MRRP 2009a) summarizes information on current watershed conditions and restoration activities that the Mattole River and Range Partnership (MRRP) intends to complete in the next 10 years. The other document is California Department of Fish and Game's *Recovery Strategy for California Coho Salmon* (CDFG 2004), which provides recommendations for high-priority recovery actions on a watershed-by-watershed basis.

The MCRS will build upon the information contained in these documents, but will result in more tailored recommendations for recovery actions based on an enhanced understanding of limiting factors by life stage, and of the current and potential spatial distribution of coho habitat in the watershed.

The MCRS will also complement National Oceanic and Atmospheric Administration National Marine Fisheries Service's (NOAA Fisheries) draft Southern Oregon/Northern California Coast (SONCC) Coho Recovery Plan, which has been in preparation since 2002, and is expected to be finalized in 2011.

C. Population Status

The coho salmon population in the Mattole is part of the Southern Oregon/Northern California Coast (SONCC) coho salmon Evolutionarily Significant Unit (ESU), comprised of populations inhabiting coastal streams from Punta Gorda, California north to Cape Blanco, Oregon. This includes coastal rivers from the Mattole River north to the Elk River in Oregon. NOAA Fisheries listed the SONCC ESU as Threatened under the Federal Endangered Species Act (ESA) in 1997 (70 FR 37160).

NOAA Fisheries' 2001 updated status review for the California portion of the SONCC ESU came to the following conclusions:

> After considering this information, we conclude that the Southern Oregon/Northern California Coast ESU is presently not at risk of extinction, but it is likely to become endangered in the foreseeable future. The conclusion is tempered by the fact that population trend data was limited, and further analysis may reveal declines sufficient to conclude that the California portion of this [SONCC] ESU is in danger of extinction.

NOAA Fisheries gives the SONCC ESU a Recovery Priority Number of "1" based on "a high magnitude of threat, a high potential for recovery, and anticipated conflict with current and future land disturbance and water-associated development within the range of the ESU" (NMFS 2001).

In 2005, the California Department of Fish and Game (CDFG) listed coho salmon from Punta Gorda north to the California-Oregon border as Threatened under the California Endangered Species Act. CDFG determined that coho salmon abundance in California, including hatchery stocks, had declined at least 70% since the 1960s, and in 2004 was only 6-15% of the abundance during the 1940s (CDFG 2004).

Additionally, Moyle et al. (2008) determined that the largest remaining populations of SONCC coho salmon in California are found in the Klamath, Trinity, Mad, Humboldt Bay, Eel, and Mattole drainages.

D. Viability and Recovery

McElhany et al. (2000) define a viable salmonid population as "an independent population…that has a negligible risk of extinction due to threats from demographic variation, local environmental variation, and genetic diversity changes over a 100-year time frame." Williams et al. (2008) expand on this definition:

> The foundation of ESU viability is built upon the ability of populations to function in an integrated manner and persist across the landscape. This integration includes dispersal among populations (i.e. connectivity) and a diversity and distribution of habitat types and conditions that allow for the expression of a range of life history types (Williams and Reeves 2003). For an ESU to be viable the number and distribution of its constituent populations would exist in a balance between connectivity through dispersal and isolation from common catastrophic risks; viable populations need to be in close enough proximity to ensure connectivity, but not so close as to have a high likelihood of being affected by the same catastrophic event.

The Mattole River coho salmon population is considered a Functionally Independent Population within its ESU (Bjorkstedt et al. 2005, Williams et al. 2006). The concept is explained in Bjorkstedt et al. (2005):

> Functionally Independent Populations are those with high likelihood of persisting over 100-year time scales and conform to the definition of independent viable salmonid populations...The concept considers independently two characteristics of a population: *viability*, defined in terms of probability of extinction over a specified time frame, and *independence*, defined in terms of the influence of immigration on a population's extinction probability...Following McElhany et al. (2000), we define a 'viable' population as a population having a low (< 5%) probability of going extinct over a 100-year time frame, and define an 'independent' population as one for which exchanges with other populations have negligible influence on its extinction risk, estimated over a similar time frame.

Williams et al. (2008) presents ESU-level and population viability criteria. The goals of the criteria ensure "sufficient genetic and phenotypic diversity," "sufficient connectivity," and buffering "against catastrophic loss of populations by ensuring redundancy (i.e. multiple viable populations)." The criteria outline the importance that all Functionally Independent Populations remain viable. For example, two of the ESU-level viability criteria include:

"All identified diversity strata that include historical functionally or potentially independent populations within an ESU or DPS [Distinct Population Segment] should be represented by viable populations for the ESU or DPS to be considered viable […]" and,

"At least fifty percent of historically independent populations (functionally or potentially independent) in each diversity stratum must be demonstrated to be at low risk of extinction […]"

In defining the latter criteria, Williams et al. (2008) divides populations into diversity strata in order to determine viability criteria for each population. The SONCC ESU is divided into 5 diversity strata consisting of 14 Functionally Independent Populations, 11 potentially independent populations, and 6 dependent populations. The Mattole River belongs to the Southern Coastal Basins diversity stratum, which needs a minimum of 11,000 spawners to satisfy the 50% low-risk requirement for the stratum to be deemed viable, thus enabling the ESU to become viable. Williams et al. (2008) reports a required spawner density threshold of 6,500 adults for the Mattole and determined a depensation level for Mattole coho of 250 adults. Depensation is defined by NOAA Fisheries to be the minimum threshold number of individuals below which the trajectory towards extinction may be irreversible.

The actual definition of recovery – in terms of salmonid population dynamics – is not exactly clear, and the details on what it means to "recover" Mattole coho salmon are not specifically stated in NOAA's technical memorandums. NOAA Fisheries (2006) defines recovery as "…the process by which listed species and their ecosystems are restored and their future safeguarded to the point that protections under the ESA are no longer needed." In terms of recovery and viability, the MCRS is using the Williams et al. (2008) spawner threshold of 6,500 adults as the goal of this recovery strategy to achieve a low risk of extinction for the Mattole population.

E. Importance of Mattole Coho Salmon Population

1. Little Influence by Hatcheries or Out-of-basin Transfers

The negative genetic consequences of artificial propagation are well documented (Waples 1991). The greatest risk of genetic impacts from artificial propagation comes from the introduction of fish (i.e., genes) from stocks that originated in other stream systems. Introgression of these non-native genes into the native gene pool is likely to result in a loss of alleles (genes) with which that species evolved in response to conditions (e.g. temperature) specific to individual stream systems. A typical outcome of this introgression would be reduced survival and reduced evolutionary potential (Waples 1991, Waples and Do 1994).

Unlike many populations in the SONCC coho salmon ESU, artificial propagation in the Mattole has been relatively limited. From 1985-1996 a total of 39,210 smolts and pre-smolts were raised from native Mattole stock and released in the watershed. The only recorded introduction of non-native coho to the Mattole were a total of 13,340 Noyo River smolts, released in 1983 and '84 (MSG 2000). The relative lack of out-of-watershed introductions ensures that extant salmonid populations in the Mattole River reflect the evolutionary legacy that resulted from the various selective pressures inherent to the Mattole River, and therefore have a high likelihood of having a positive demographic response to restoration actions that reduce the existing stressors on the populations.

2. Southern Extent of SONCC Coho Salmon

Coho salmon in the Mattole River represent the southern extent of the SONCC ESU. As such, they may be more genetically differentiated from populations nearer the center of their range, and thus contribute significantly to their respective species' total genetic diversity and evolutionary potential (Scudder 1989; Lesica and Allendorf 1995). With the predicted effects of climate change on watersheds and salmonid habitat in the coming decades (Bisson 2008), population genetics from the southern portion of the range of coho salmon may be particularly important to the population as a whole.

3. Free Flowing River

Dams impact salmon in a number of ways including blockage of spawning and rearing habitat, inundating spawning habitat, modifying historical flow patterns, and increasing temperatures and algal concentrations. The Mattole River mainstem contains no dams and thus, salmon have full access to their historic spawning habitat. Although a few documented fish passage barriers do occur on tributaries due to road crossings, the vast majority of these barriers have recently been removed or are targeted for removal.

4. Closed Fishery

Harvest of wild salmonids is prohibited in the Mattole River Watershed. CDFG allows a catch and release fishery in the lower 26 miles of the river from January 1 to March 31, as well as the fourth Saturday in May through August 31 in the majority of the lower 26 miles, dependent on flows. Although catch and release is permitted for coho salmon, the majority of angling is focused on steelhead.

5. Rural Landscape

Low human population densities, large land parcels, and a relatively undeveloped land base are a few reasons the Mattole River Watershed is capable of supporting stable salmonid populations. As a result, Mattole salmonids exist in a river system which lacks virtually any contaminants commonly found in urban stormwater runoff. An additional benefit to salmonids resulting from the rural Mattole landscape is that industrial water withdrawals (and associated discharge) are close to nonexistent. Mattole salmon share this rural landscape with a human population that is generally respectful and supportive of salmon restoration. In addition, 24% of land within the Mattole is managed for conservation values: 22% by the Bureau of Land Management (BLM) and the State of California, and the remainder under conservation easements on private land.

6. Past, Present, and Future Restoration Efforts

The Mattole River Watershed has been and continues to be the site of one of the most extensive efforts geared towards restoration of local native salmonids in the country. A remarkable number of parties have undertaken restoration efforts in the Mattole. These include citizens and landowners, volunteers, nonprofit organizations, private foundations, and county, state, and Federal agencies.

Past and present restoration efforts in the Mattole are unique in that they include comprehensive and complimentary work completed instream as well as upslope. Instream efforts have included rescue rearing, placement of large wood habitat structures, bank stabilization, fish passage barrier removal, streamflow enhancement, and slough and estuarine habitat enhancement. Upslope restoration efforts have included tree planting, riparian restoration, forest health and fire hazard reduction, timber harvest review, invasive plant control, water conservation, and a comprehensive sediment reduction initiative. Sediment reduction efforts have been completed in over half of the watershed, including road drainage improvements, stream crossing upgrades, and road decommissioning. Additionally, the Mattole Flow Program – developed to address extreme summer low flows – is the first of its kind in California and has demonstrated marked success in reducing impacts of human water withdrawal on summer streamflows. Dedicated parties in the Mattole have also ensured that local students of all ages are active in watershed and salmonid restoration by including ecological education and restoration internships as essential elements of the MRRP. For more information on the history and extent of Mattole restoration efforts, please refer to MRC et al. 2005 and MRRP 2009a, as well as *Appendix C* of this document.

Future endeavors that will complement and further the work already completed in the Mattole include efforts to stave off ecologically harmful subdivisions in this rural watershed, intensified efforts to conserve instream flows in critical reaches of tributaries and the mainstem Mattole River, and identification and control of aquatic invasive species and harmful toxins and nutrients levels in the watershed.

Past, current, and future restoration efforts in the Mattole are noteworthy on three levels. First, the length of time – 30 years – and degree and range of collaboration among parties whose common goal is the restoration of native salmon is remarkable. Second, the fact that the MRRP has undertaken such comprehensive efforts, treating the entire watershed as salmon habitat, stands out as pioneering and innovative. Lastly, the reality that so many entities are still actively engaged in this unfinished task merits attention. The extent of past restoration efforts and a commitment to continue this work has set the MRRP up for success in the restoration of Mattole River coho salmon.

II. Mattole Coho Abundance and Distribution

A. Historic

1. Abundance

In 1960 the U.S. Fish and Wildlife Service (USFWS) made potential and current coho salmon population estimates for the Mattole River Watershed based on spawning gravel surveys and interviews with local residents and anglers. USFWS estimated a potential total population of 20,000 adults and estimated a then-current population of 2,000 adults (Downie et al. 2003).

Based on results from their RIPPLE coho salmon population model, Stillwater Sciences also estimated a potential long-term average abundance of up to 20,000 coho adults (F. Ligon, Stillwater Sciences, Arcata, CA, pers. comm., 2010). The RIPPLE model uses data on physical habitat characteristics, such as stream gradient and confinement, and habitat use and suitability information by life-stage to predict reach-specific potential habitat conditions and long-term average abundance (Dietrich and Ligon 2008).

2. Distribution

Information and data from Brown and Moyle (1991), CDFG (Downie et al. 2003, M. Gilroy pers. comm. July 7, 2009, Jong et al. no date), Coastal Headwaters Association (CHA 1982), Mattole Salmon Group, Stillwater Sciences, and NOAA Fisheries (Williams et al. 2008) were used to determine historic, past, and current coho distribution in the Mattole River watershed. Table 1 (pgs. 13-14) compares information from these various sources.

Potential spawning (Figure 1) and rearing (Figures 2 and 3) habitat and coho densities predicted by the RIPPLE model in the Mattole River Watershed are shown on the following pages. In addition, NOAA Fisheries modeled the intrinsic potential (IP) of stream reaches in the Mattole to support coho salmon (Figure 4). Williams et al. (2008) provides the following description of IP:

> IP… predicts the potential for a stream reach to exhibit habitat characteristics as a function of the underlying geomorphic and hydrologic characteristics of the landscape… These characteristics are selected on the basis of being effectively constant features of the landscape that directly control the processes that create, alter, and maintain essential features of salmon habitat.
>
> Specifically, IP is calculated as the geometric mean of suitability scores… which are generated by mapping the values for each of three habitat characteristics (i.e. mean gradient, mean annual discharge, and valley constraint) onto suitability curves. The IP model itself has the structure of a limiting factors analysis, in that a low suitability score for a single habitat characteristics can greatly reduce (or eliminate) the potential for suitable habitat.

IP values can range from 0 – 1. Stream reaches with values closer to 1 have a greater potential, based on their channel gradient, valley width, and drainage area, to contain more suitable habitat characteristics for coho salmon than reaches with values closer to 0.

Note that the IP model and the RIPPLE model are an expression of the *potential* suitability of habitat for use by coho salmon. Landscape attributes which were not among those used in the models or other factors may preclude a stream or reach which is *predicted* to offer potential habitat from actually providing suitable habitat for coho salmon. Natural fish passage barriers too small to be captured by the model may also preclude fish access to some reaches that are otherwise shown as providing suitable habitat.

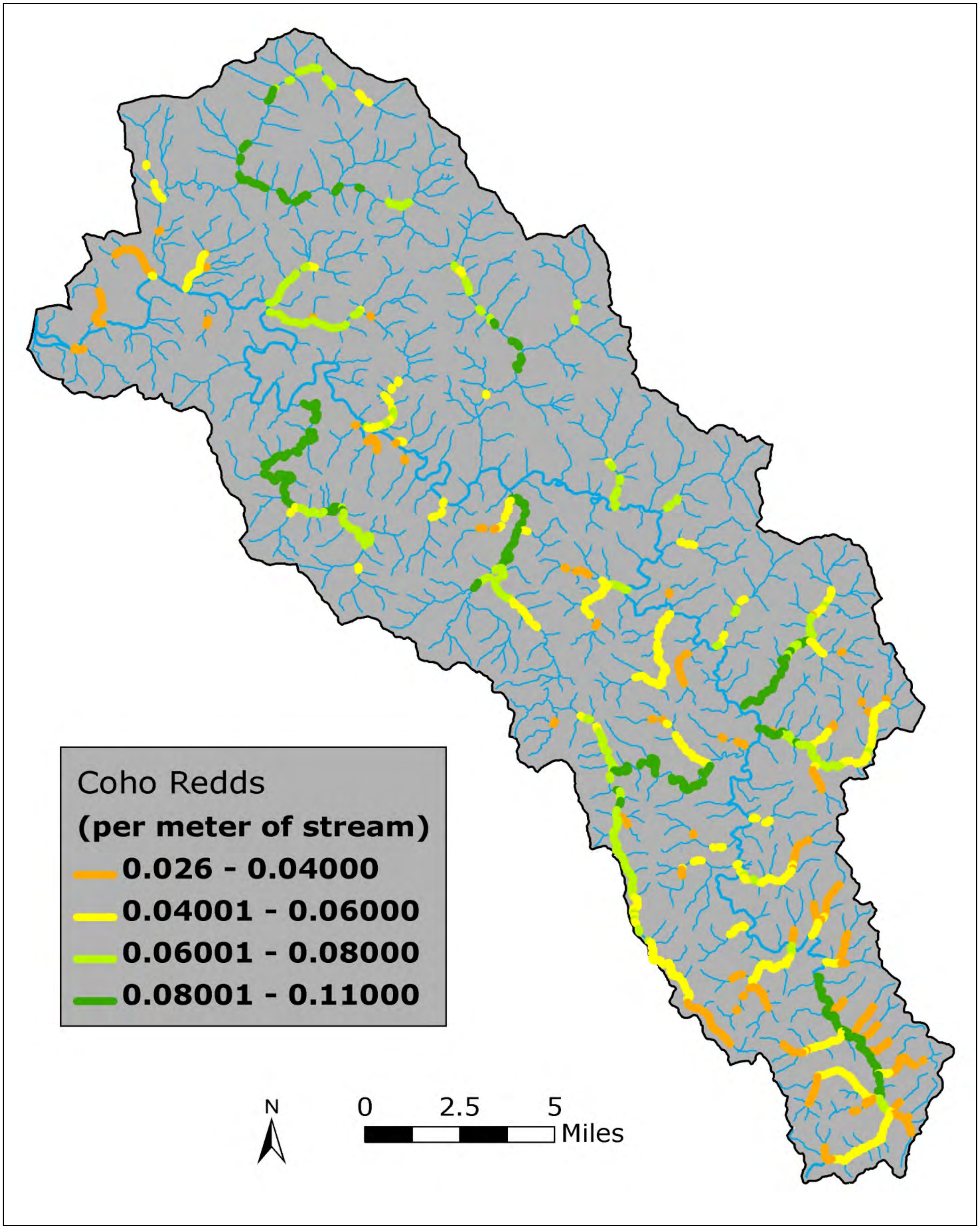


Figure 1. Predicted spawning habitat suitability: potential number of coho redds per meter of stream based on RIPPLE Coho Salmon Population Model.

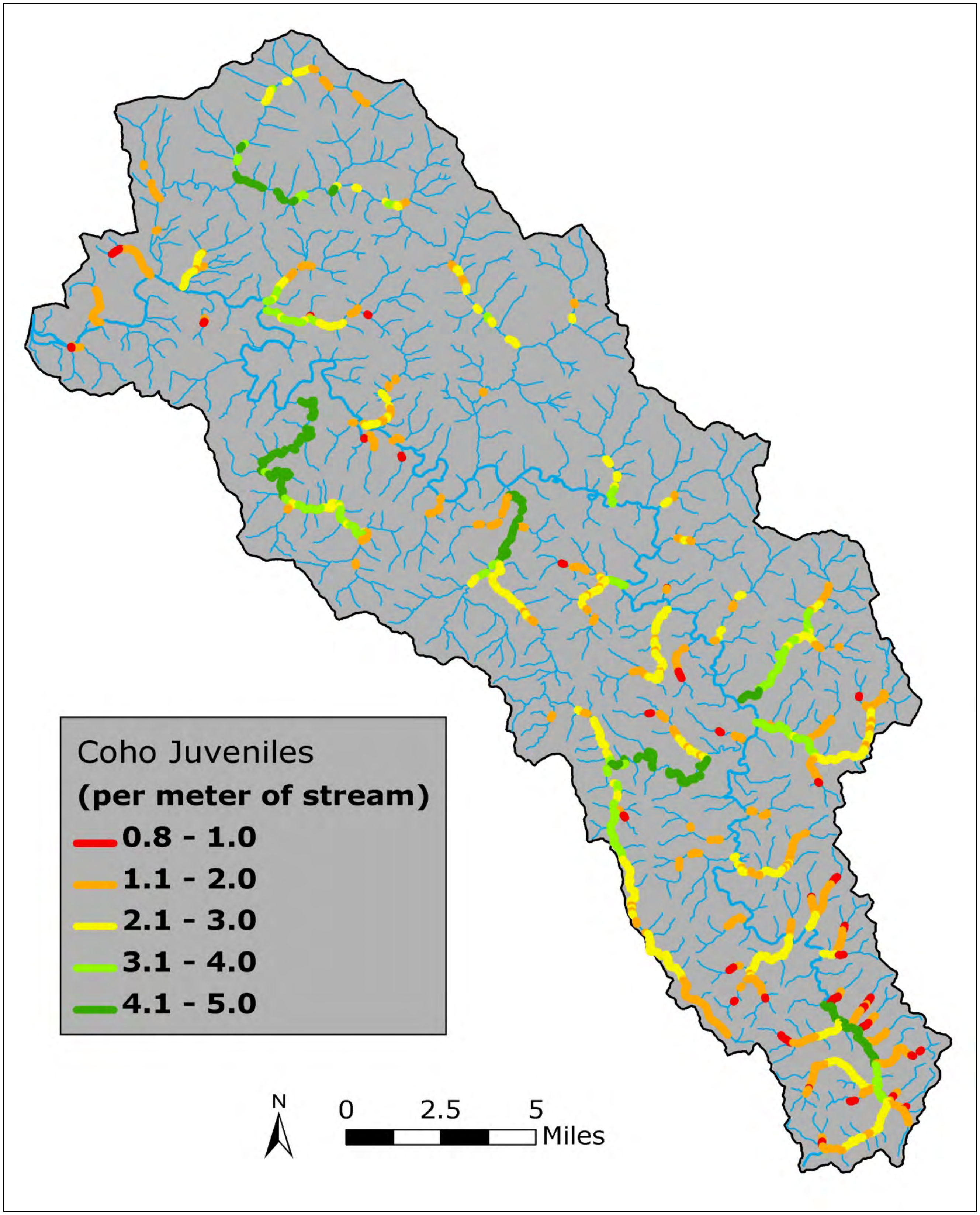


Figure 2. Predicted summer rearing habitat suitability: potential number of coho juveniles per meter of stream based on RIPPLE Coho Salmon Population Model.

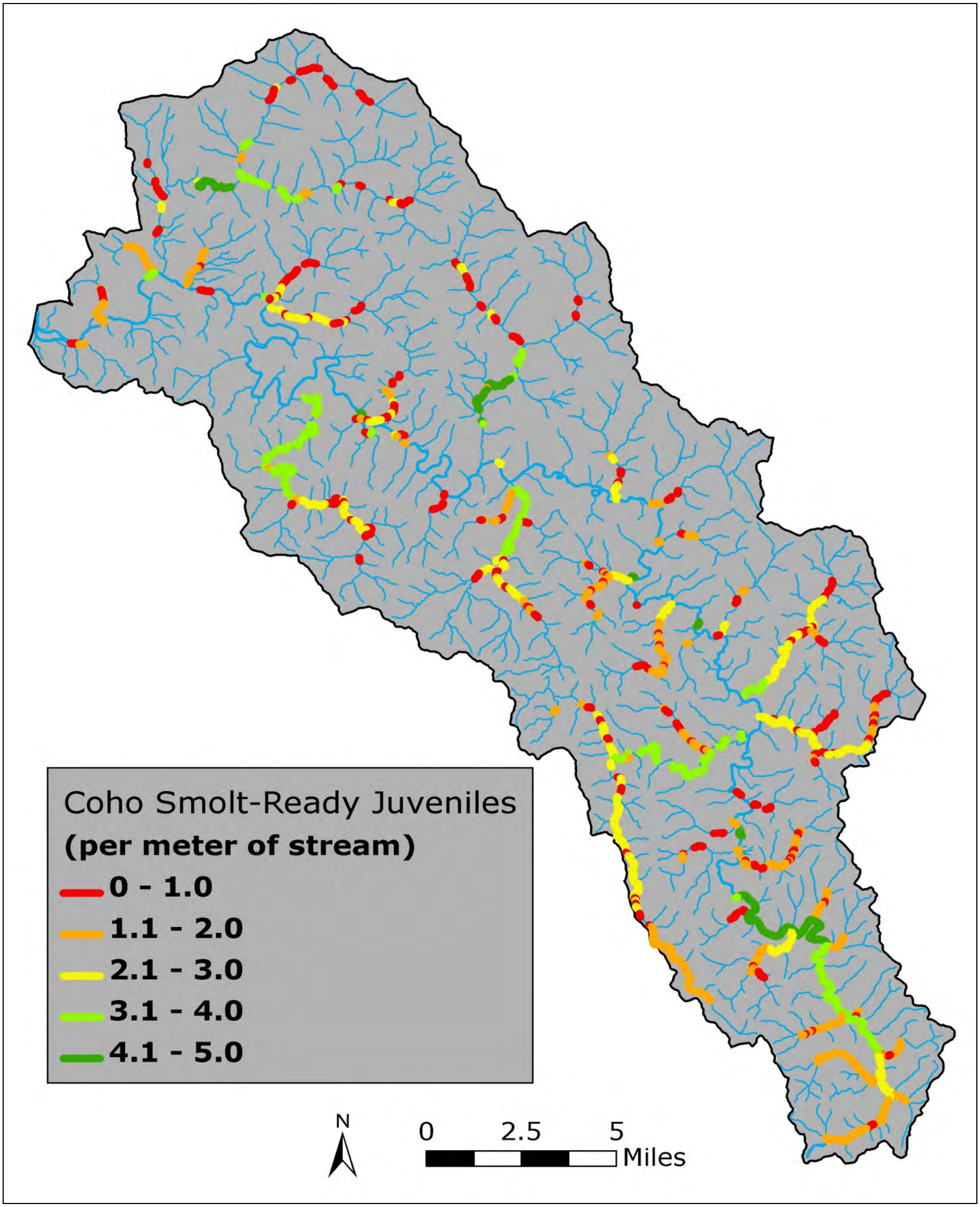


Figure 3. Predicted winter rearing habitat suitability: potential production of coho smolt-ready juveniles per meter of stream based on RIPPLE Coho Salmon Population Model.

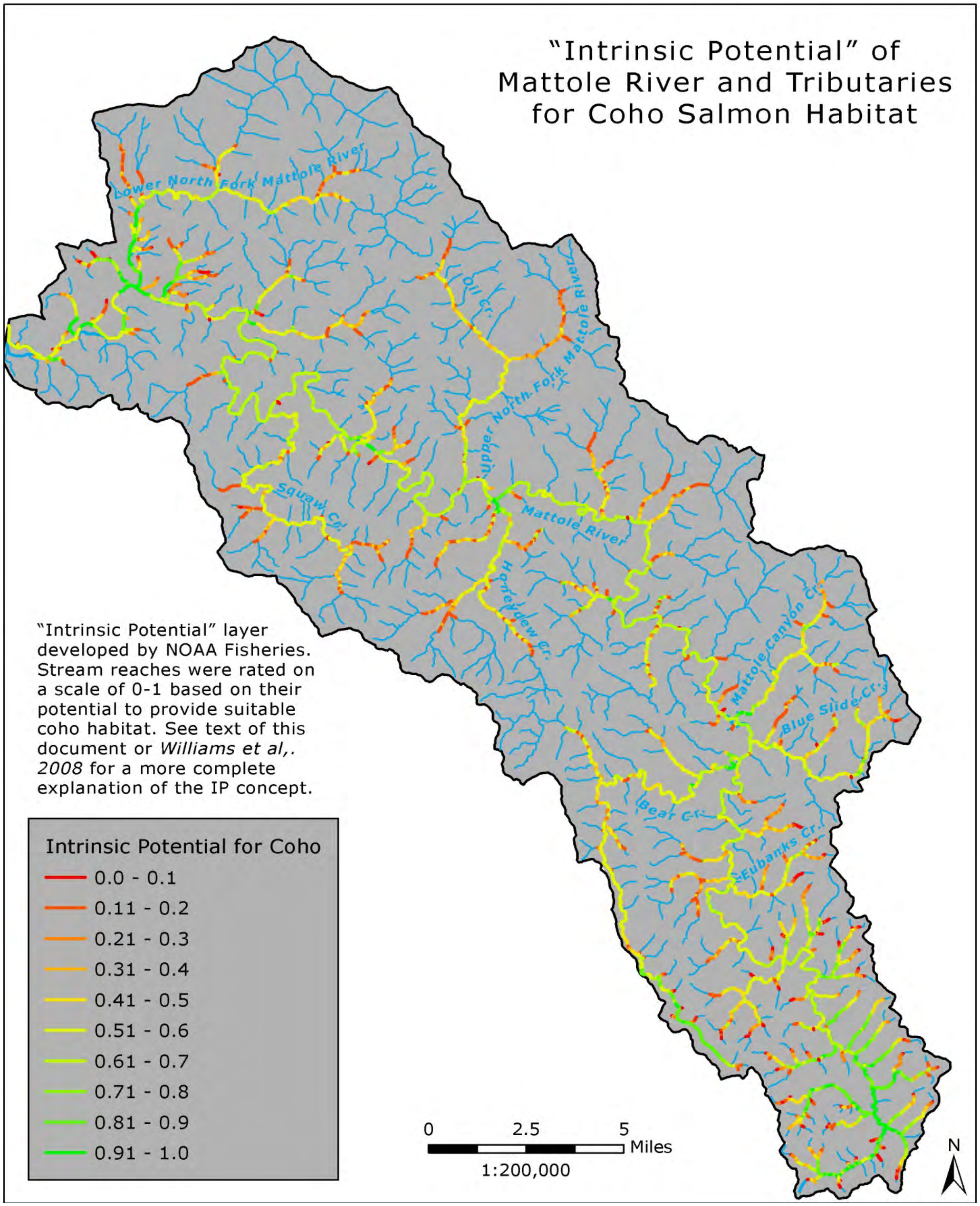


Figure 4. Distribution of the Mattole River Watershed's "Intrinsic Potential" for coho salmon habitat.

Table 1. Mattole River Watershed historic coho distribution and potential habitat based on various data.

Approx. River Mile (RM)	Subbasin Name	Historic Coho Streams[1]	CDFG Coho Juvenile Presence 1979-1984[2]	CDFG Coho Juvenile Presence 1985-2010[2]	MSG Coho Juvenile Presence 1985-2002[3]	MSG Coho Juvenile Presence 2003-2009[3]	Coho Redds Observed 1995-2009[4]	Suitable Potential Habitat in RIPPLE Model[5]	IP Kilome -ters[6]	Rank based on IP KM (smaller # has higher IP)[7]
1.0	Lower (Little) Bear	x	Y		Y	N		x	0.10	69
1.3	Stansberry				N	N		x	0.59	56
1.8	Jim Goff							xx	1.70	34
2.8	Lower Mill	x	Y	Y	Y	Y	N	*	*	*
4.7	Lower North Fork Mattole				Y	N	N	xx	11.60	5
5.4	East Mill	x	N	Y	N	Y	N	xx	4.87	12
6.1	Clear	x	Y	N	N	Y	N		0.07	71
7.8	Conklin				Y	N		xx	2.25	27
8.0	McGinnis					N	N	xx	3.59	17
11.7	Indian	x	Y	Y			N		0.58	57
14.9	Squaw	x	Y	Y	Y	Y	N	xx	11.81	4
19.2	Pritchett							xx	2.50	23
19.2	Granny							x	0.87	46
19.9	Saunders				N	N		x	0.33	61
24.1	Woods	x		Y	N	Y		xx	0.95	45
25.5	Upper North Fork Mattole	x		N	Y	N		xx	5.82	9
26.5	Honeydew (excluding Lower E. Fk. & Bear Trap)	x	N	Y	Y	N	N	xx	5.47	10
26.5 +2.5	Honeydew, Lower East Fork	x			Y	N	N	xx	2.34	25
30.4	Dry				N	N		xx	1.99	29
31.3	Middle				N				0.82	47
31.7	Westlund	x		Y	Y			x	1.12	42
32.8	Gilham				N	N		x	0.37	60
34.6	Fourmile	x		Y		Y	N	xx	2.64	22
36.6	Sholes	x		Y		N		xx	1.80	31
39.0	Grindstone	x	N	Y	N	N		xx	*	*
41.1	Mattole Canyon	x	N	N	Y	N	N	xx	6.83	8
42.0	Blue Slide	x		Y	N	N		xx	9.23	6
42.8	Bear (excluding N&S forks)	x	N	Y	Y	N	Y	xx	8.71	7
42.8	N. Fork Bear	x		Y	Y	N	N	xx	1.73	33
42.8	S. Fork Bear	x		Y	Y	N	Y	xx	12.28	3
44.0	Wolf/ Box Canyon	x		Y					0.32	62
45.9	Deer Lick				Y	N		x	1.53	36
46.8	Little Finley				Y			x	0.98	44

Approx. River Mile (RM)	Subbasin Name	Historic Coho Streams[1]	CDFG Coho Juvenile Presence 1979-1984[2]	CDFG Coho Juvenile Presence 1985-2010[2]	MSG Coho Juvenile Presence 1985-2002[3]	MSG Coho Juvenile Presence 2003-2009[3]	Coho Redds Observed 1995-2009[4]	Suitable Potential Habitat in RIPPLE Model[5]	IP Kilome -ters[6]	Rank based on IP KM (smaller # has higher IP)[7]
47.4	Big Finley	x	N	Y	Y	Y	N	x	1.81	30
47.7	Eubanks	x	Y	Y	Y	N	N	xx	4.12	16
50.2	Nooning				N			x	0.75	49
52.1	Bridge	x	N	Y	Y	Y	N	xx	4.71	13
52.8	McKee	x	Y	Y	Y	Y	Y	xx	2.44	24
54.0	Van Arken	x	N	Y	Y	Y	Y	xx	3.41	18
55.6	Anderson	x		Y	N	N		x	0.64	52
55.8	Ravasoni (East Anderson)	x		Y				x	1.46	38
56.2	Upper Mill	x	Y	Y	Y	Y	Y	xx	3.28	20
56.5	Harris	x	N					xx	2.08	28
56.8	Gibson	x						x	1.42	39
57.1	Stanley	x	Y	N			N	x	1.80	32
57.6	Baker	x	Y	Y	Y	Y	Y	xx	3.21	21
58.4	Thompson	x	Y	Y	Y	Y	Y	xx	5.04	11
58.4 +2.2	N. Fork Thompson (Danny's)	x		Y	Y	Y	Y		0.66	51
58.4 +0.13	Yew (trib. to Thompson)	x	N	Y	Y	Y	Y	xx	1.33	40
58.7	Helen Barnum	x		Y	N	Y	N	x	1.20	41
58.8	Lost River	x		Y	Y	Y	N	xx	3.07	15
60.8	Ancestor	x		Y	Y	Y	Y	x	1.02	43
60.8 +0.15	McNasty (trib. to Ancestor)	x		Y	Y	Y			0.73	50
56.5	Mainstem above Whitethorn	x			Y	Y	Y	xx	13.38	2

[1] *Historic data based on Brown and Moyle (1991), Downie et al. (2003), and Jong et al. (no date)*
[2] *CDFG data based on snorkel surveys, minnow trapping, and electrofishing (CHA 1982, Downie et al. 2003; Jong et al. (no date), M. Gilroy pers. comm. July 7, 2009)*
3Mattole Salmon Group (MSG) data based on snorkel surveys (MSG unpublished data)
[4] *MSG data based on spawning ground surveys (MSG unpublished data)*
[5] *Based on 2010 run of Stillwater Sciences RIPPLE model for the Mattole River Watershed (Stillwater Sciences, Arcata, CA. Extent of predicted habitat per tributary was visually estimated from RIPPLE maps (Figures 1-3, with: x = < 1 km habitat, xx = >1 km potential habitat.*
[6]*Values from NOAA Fisheries Intrinsic Potential data* [layer] *(GIS layer obtained from NOAA Fisheries, Santa Cruz, CA). "IP KM" is the weighted IP value for a reach (0= habitat potential, 1=greatest habitat potential) multiplied by the length of the reach, and summed for each tributary. The lowers "IP KM" value represents the quality and extent of habitat potential for each stream.*
[7] *Ranking of the IP KM values. Note that the Mattole River mainstem is #1, and is not shown in the table.*
**Grindstone Creek and Lower Mill Creek were assigned IP values of 0 in the IP GIS layer obtained from NOAA. This is an apparent error, as some reaches within these watersheds should have IP > 0 based on the IP suitability curves in Williams et al. 2008.*

B. 1980-Present

1. Adults

a. Data Gaps

Exact escapement estimates are difficult to determine in the Mattole due to high flow events, private property access, and funding. Coho adults migrate into the river in the fall when rainfall and resulting river flows are high enough to breach the lagoon sandbar and open the river mouth. Adults continue to move further up the system as flows allow. Coho salmon primarily migrate during high flows and at night in the Mattole River Watershed. Stormflows in the Mattole are powerful enough to preclude the safe operation of a weir to capture the migrating adults. Funding constraints have not allowed us to solidify other options, such as a DIDSON™ acoustic sonar unit.

Adults, carcasses, and redds are observed and tallied during spawner surveys. The Mattole Salmon Group (MSG) has access to conduct surveys in the majority of the watershed, however there are a few select areas that may contain coho that we are not able to survey, such as Squaw Creek (the fifth largest tributary to the Mattole River). In addition, surveys in the lower mainstem Mattole and some lower-river tributaries (below river mile (RM) 26, approximately) are difficult to survey due to persistent turbidity following storms. Survey efforts have largely focused on headwaters tributaries and the upper mainstem where coho and Chinook are seen most consistently. While data from spawner surveys do not constitute an adult population estimate, the MSG has confidence in their value as an index of relative year-to-year abundance.

b. Abundance

The MSG has been observing and documenting salmonid abundance and distribution in the Mattole River Watershed since 1980. From 1981 to 2000, annual adult population estimates were made based on adult trapping, spawner surveys, and anecdotal evidence and historical knowledge. Within this timeframe, population estimates ranged from 1,000 (1987-88) to 50 (1989-90), with a mean of 284 adults (Figure 5).

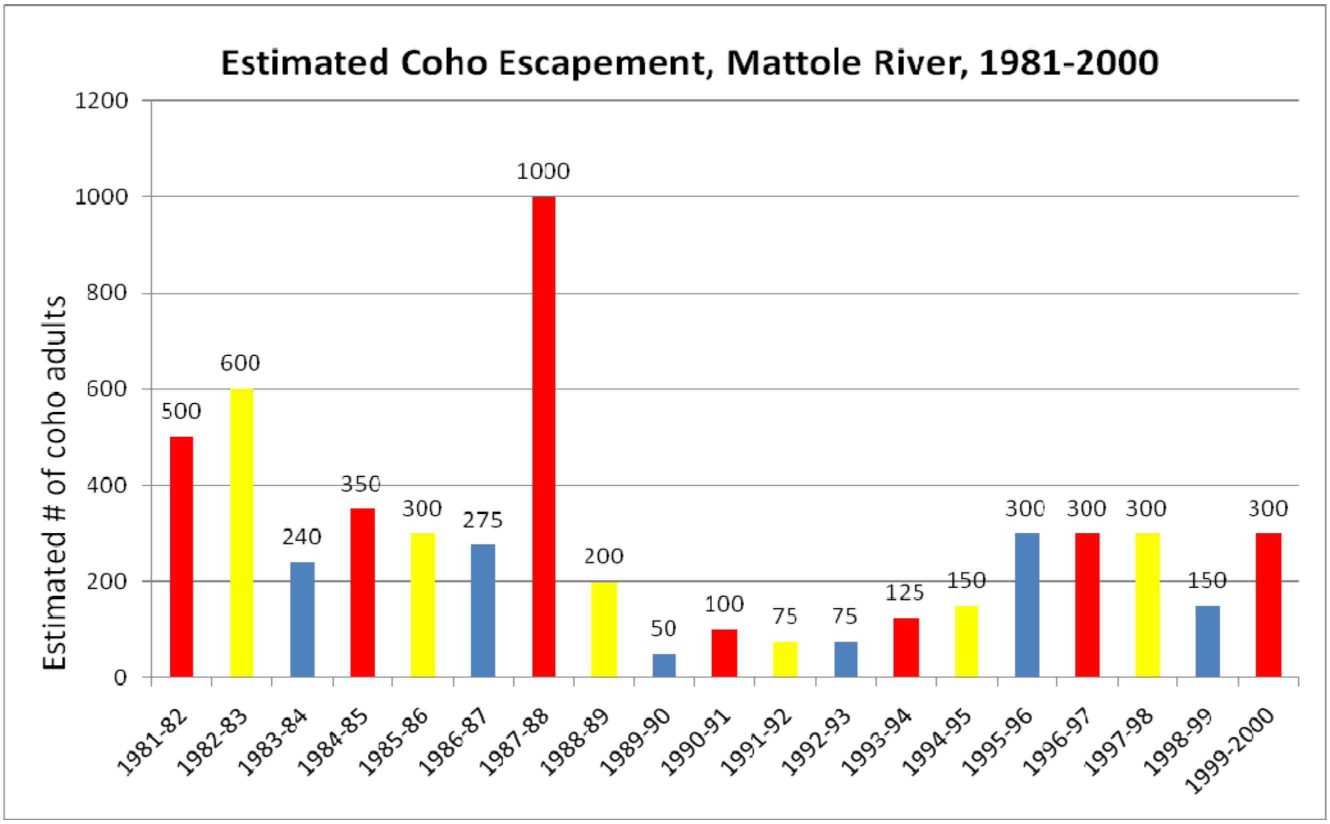


Figure 5. Mattole River Watershed adult coho salmon population estimates, 1981-2000.
Note: colors signify cohorts based on a 3-year life history.

As in other regional watersheds, accurate population estimates in the Mattole are difficult to obtain due to the aforementioned reasons. Since 1994, the MSG uses an Escapement Index (EI), which is a measure of redds observed per accumulated survey mile, in order to compare trends in population abundance since 1994. For the past 16 years (1994-95 to 2009-10 survey seasons), the escapement index has ranged from 0.01 coho redds per accumulated survey mile (2009-10) to 1.05 (1996-97) (Table 2, Figure 6). The mean for this 16-year period was 0.31 redds per accumulated survey mile.

From 1994-2010, the number of live adult coho salmon observed ranged from 86 (2004-05) to 3 (2009-10) with a mean of 34; carcasses observed ranged from 38 (2001-02) to 0 (2008-09 and 2009-2010), with a mean of 10; redds observed ranged from 68 (2004-05) to 1 (2009-10) with a mean of 29 (Table 2; Figure 6). Spawner surveys during 2009-10 documented the lowest number of live adults, carcasses, and redds on record of the last 16 years. The sole redd documented in 2009-2010 was in Danny's Creek, as was one of the three live coho adults observed. The other two fish were observed in the mainstem Mattole upstream of RM 57.0. In addition, no live adults were seen migrating in the lower river during 2009-10 spawner surveys, which is in contrast to the previous six years surveyed.

Table 2. Mattole coho salmon spawning ground survey data, including live fish, carcasses, redds, and Escapement Index (EI), 1994-95 through 2009-10 seasons.

Survey Season	**Miles of Stream Surveyed**	**Accumulated Survey Miles**	**Live Coho Observed**	**Coho Carcasses**	**Coho Redds**	**EI for Coho** (average # redds per accumulated survey mile)
1994-95	26.40	39.40	7	3	15	0.38
1995-96	44.40	65.40	8	0	7	0.11
1996-97	28.15	47.70	21	11	50	1.05
1997-98	45.2	95.40	22	3	34	0.36
1998-99	66.85	141.00	14	7	8	0.06
1999-00	68.35	151.00	29	2	23	0.15
2000-01	78.20	162.85	14	6	17	0.10
2001-02	34.05	114.35	68	38	53	0.46
2002-03	55.75	119.85	64	12	30	0.25
2003-04	42.75	77.15	44	13	40	0.52
2004-05	78.01	99.30	86	29	68	0.68
2005-06	88.08	123.64	49	12	15	0.12
2006-07	70.89	100.76	29	6	18	0.18
2007-08	87.51	147.65	52	4	31	0.21
2008-09	92.77	139.83	11	0	9	0.06
2009-10	55.15	128.80	3	0	1	0.01

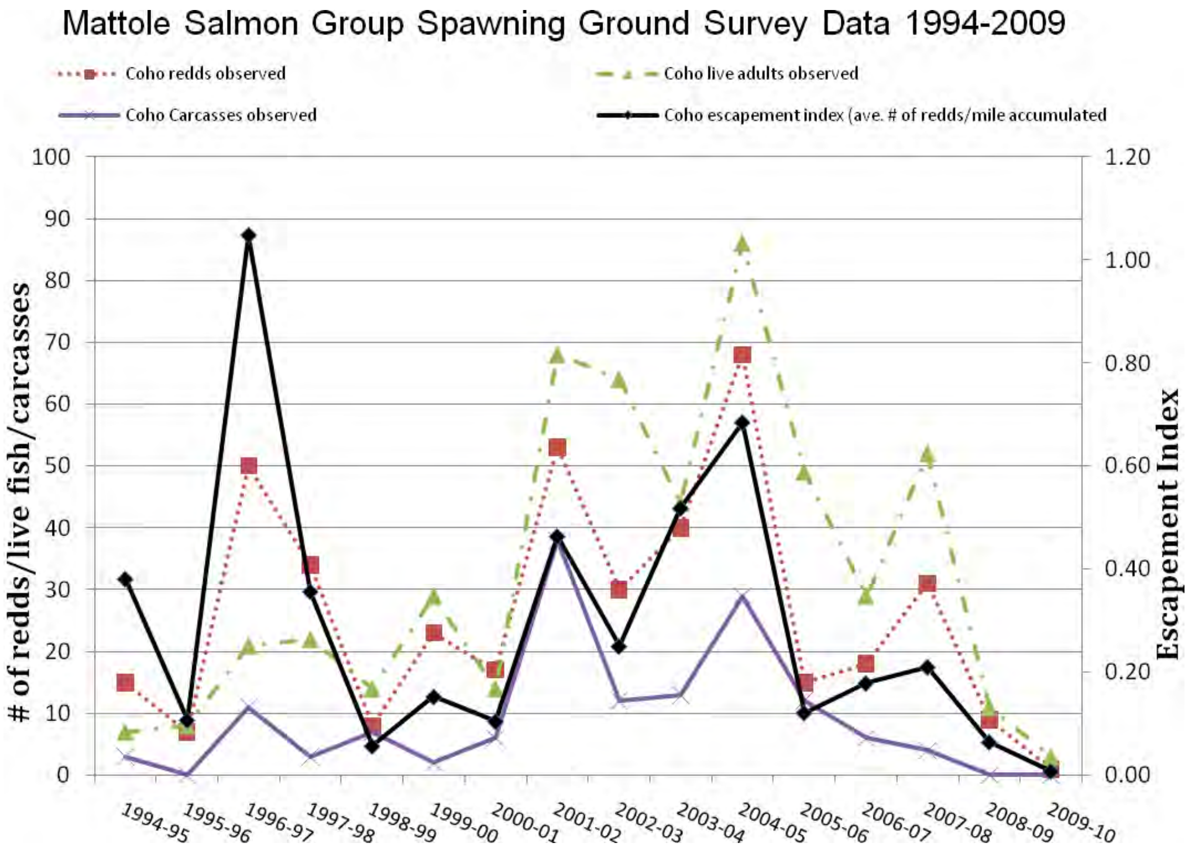


Figure 6. Mattole coho salmon spawning ground survey data, including live fish, carcasses, redds, and Escapement Index, 1994-95 through 2009-10 seasons.

The extremely low numbers of coho observed in 2008-09 and 2009-10 are part of a trend of considerable decreases in each cohort since the 2002-03 season (Figure 7). The EI for the 2002-03 population was 0.25, which decreased by 51% in 2005-2006 to 0.12, and then further decreased by another 46% in 2008-09 to 0.06. Worse yet, the EI for the 2003-2004 population was 0.52 and then decreased by 65% when returning in 2006-2007 to 0.18, which then further decreased an additional 95% in 2009-210 to 0.01. A similar trend in returns occurred for the 2004-05 cohort, which had an EI of 0.68 that then decreased by 68% in 2007-08 to 0.21. This trend of declining adult escapement in the Mattole is similar to observations from other watersheds in Northern California (see Figure 35, pg. 77; Ettlinger et al. 2009b, and MacFarlane et al. 2008).

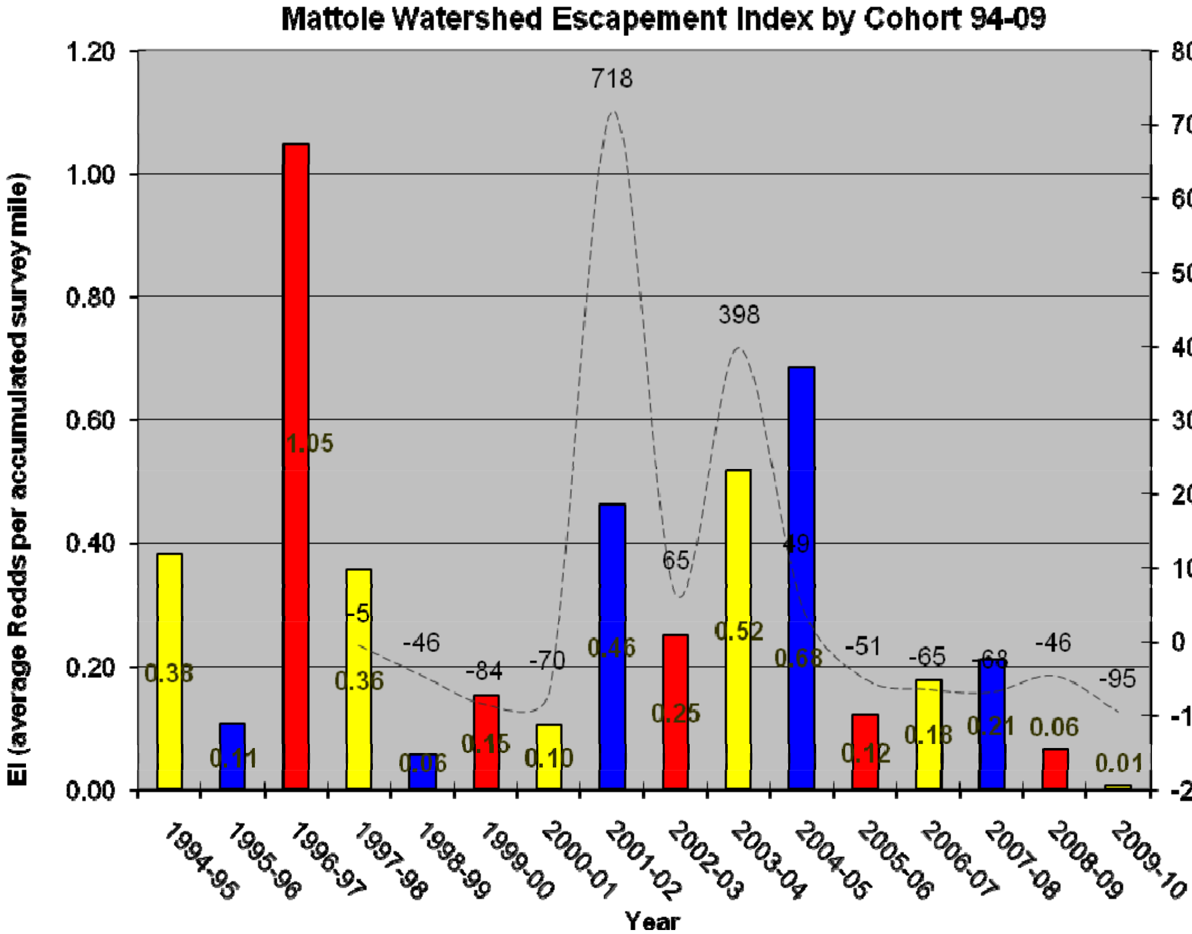


Figure 7. Percentage change in Escapement Index for returning coho cohorts during the 1994-95 through 2009-10 seasons.
Note: colors signify cohorts based on a 3-year life history.

c. Distribution

The overwhelming majority of coho spawning in the Mattole mainstem appears to occur above RM 52, upstream from the confluence with Bridge Creek (Figures 8-11). In only three years since 1994 has coho spawning in the mainstem been documented downstream of RM 52: in 1999-00 between RM 42.0-47.4, in 2000-01 between RM 32.0-47.4, and in 2004-05 between RM 48.5-52.8. In 1999-00 and 2000-01 late and weak winter rains and resulting low flows most likely played a significant role in the incidence of spawning lower in the system than what is usually observed.

Coho spawning in Mattole tributaries is also concentrated in the upper extent of the watershed. Since 1994, documented spawning in tributaries has occurred solely upstream of RM 52.1, with the exception of the Bear Creek drainage.

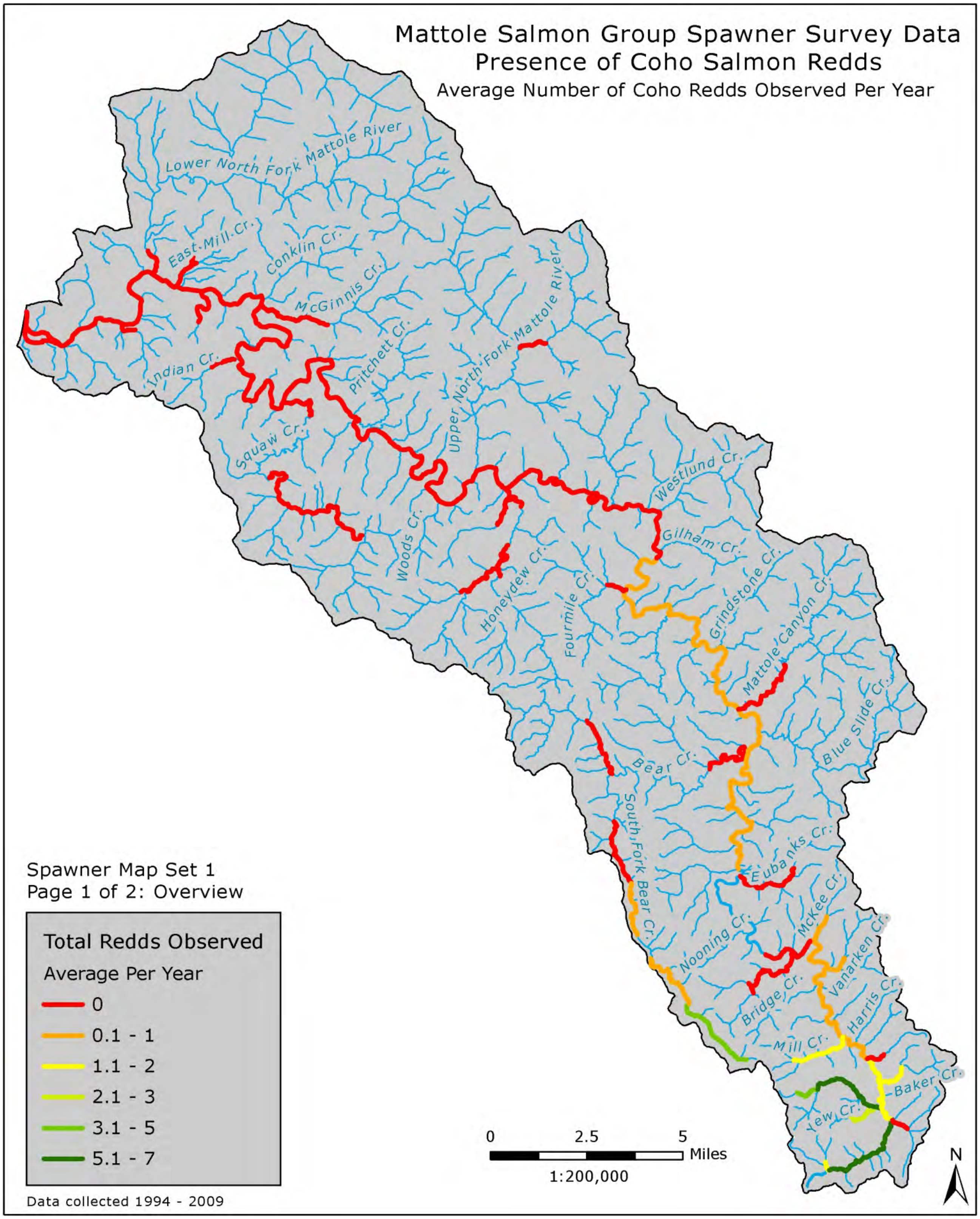


Figure 8. Average number of coho redds observed per reach, per year, in the Mattole River Watershed, MSG spawner surveys, 1994-95 through 2009-10 seasons.

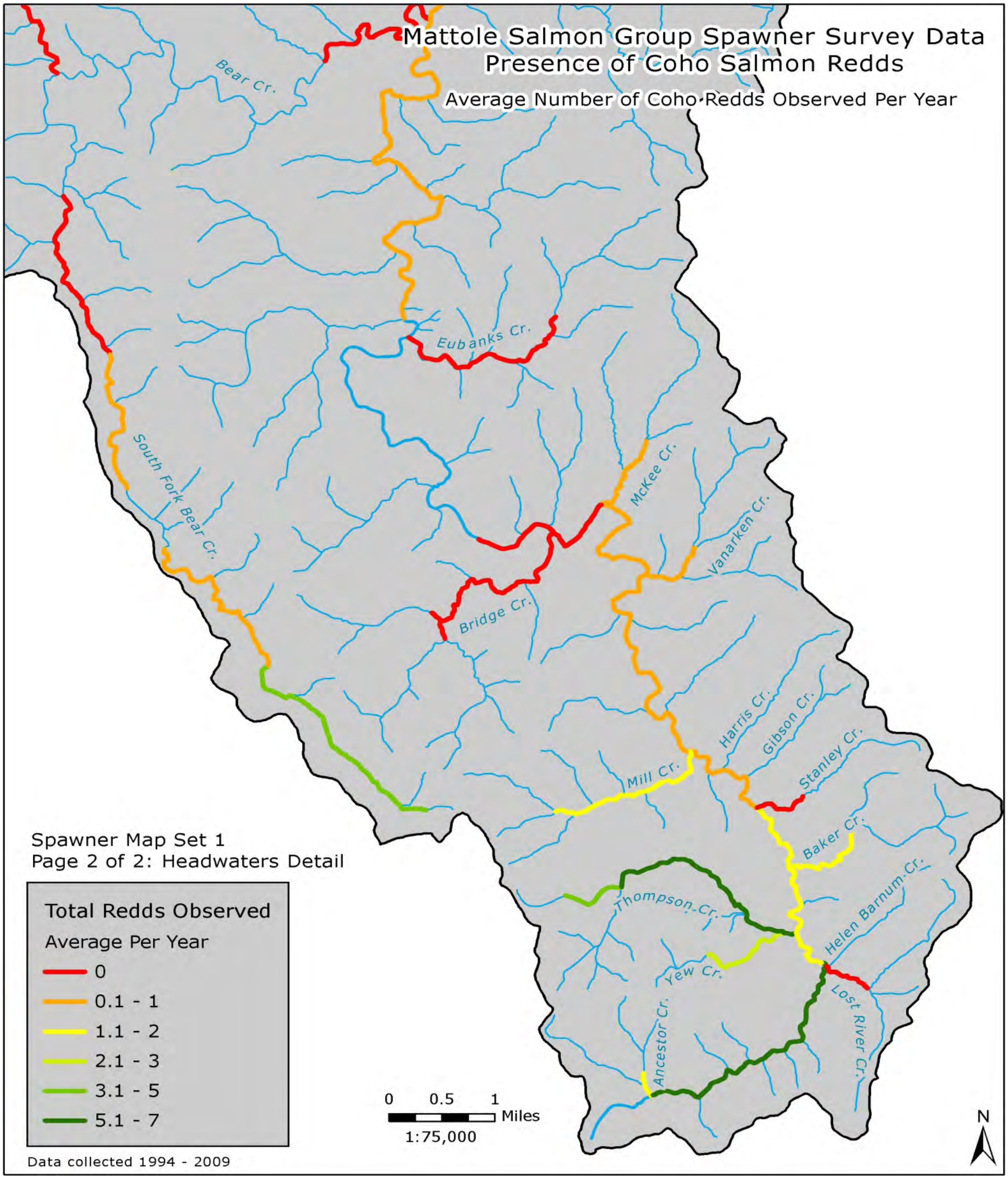


Figure 9. Average number of redds observed per reach per year from upper Bear Creek (RM 42.8) to the headwaters (RM 63.0) in the Mattole River Watershed, MSG spawner surveys, 1994-95 through 2009-10 seasons.

Note: detail shows all reaches where average number of redds observed per year is greater than 1.0.

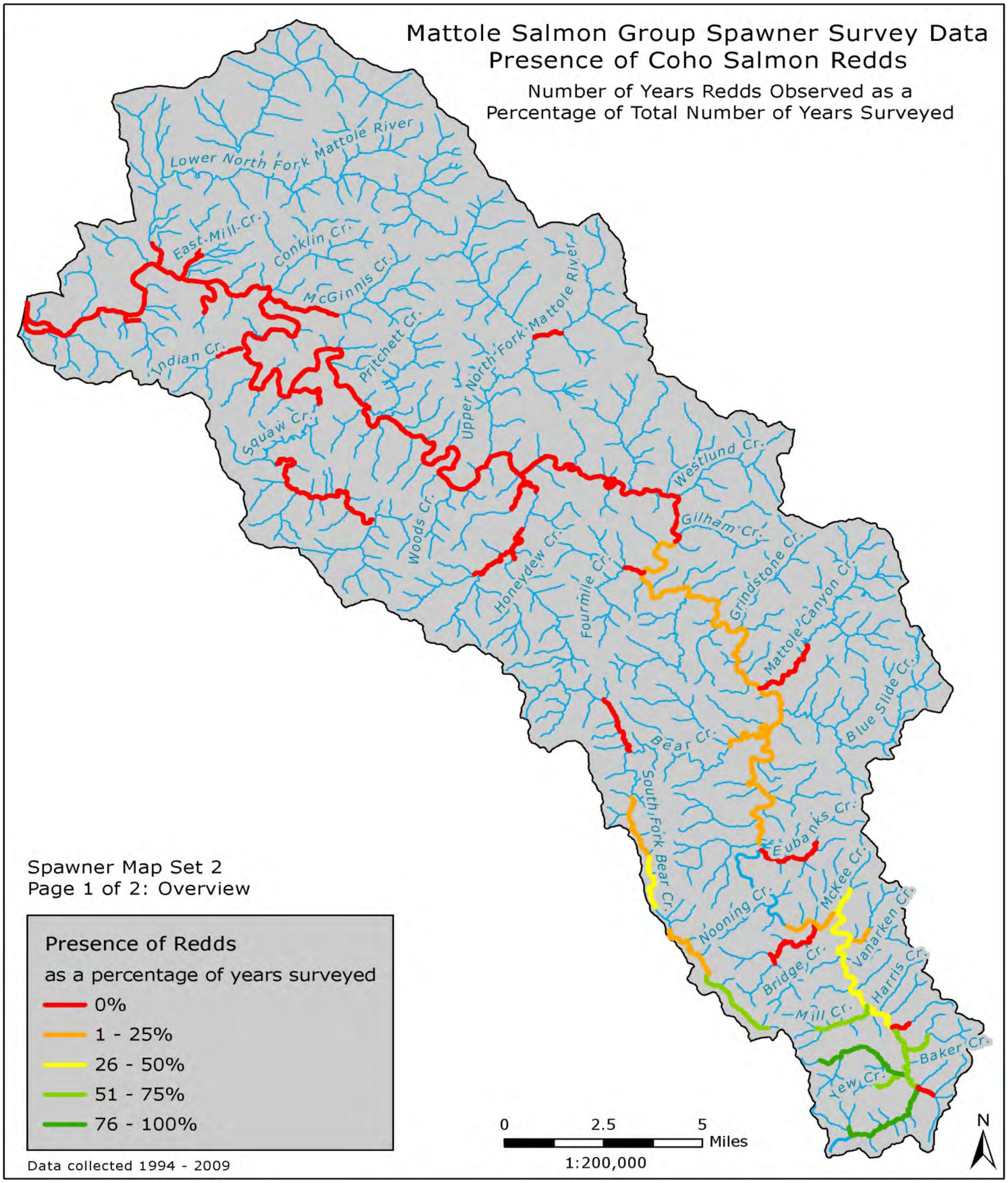


Figure 10. Presence of coho salmon redds as a percentage of years surveyed in the Mattole River Watershed, MSG spawner surveys, 1994-95 through 2009-10 seasons.

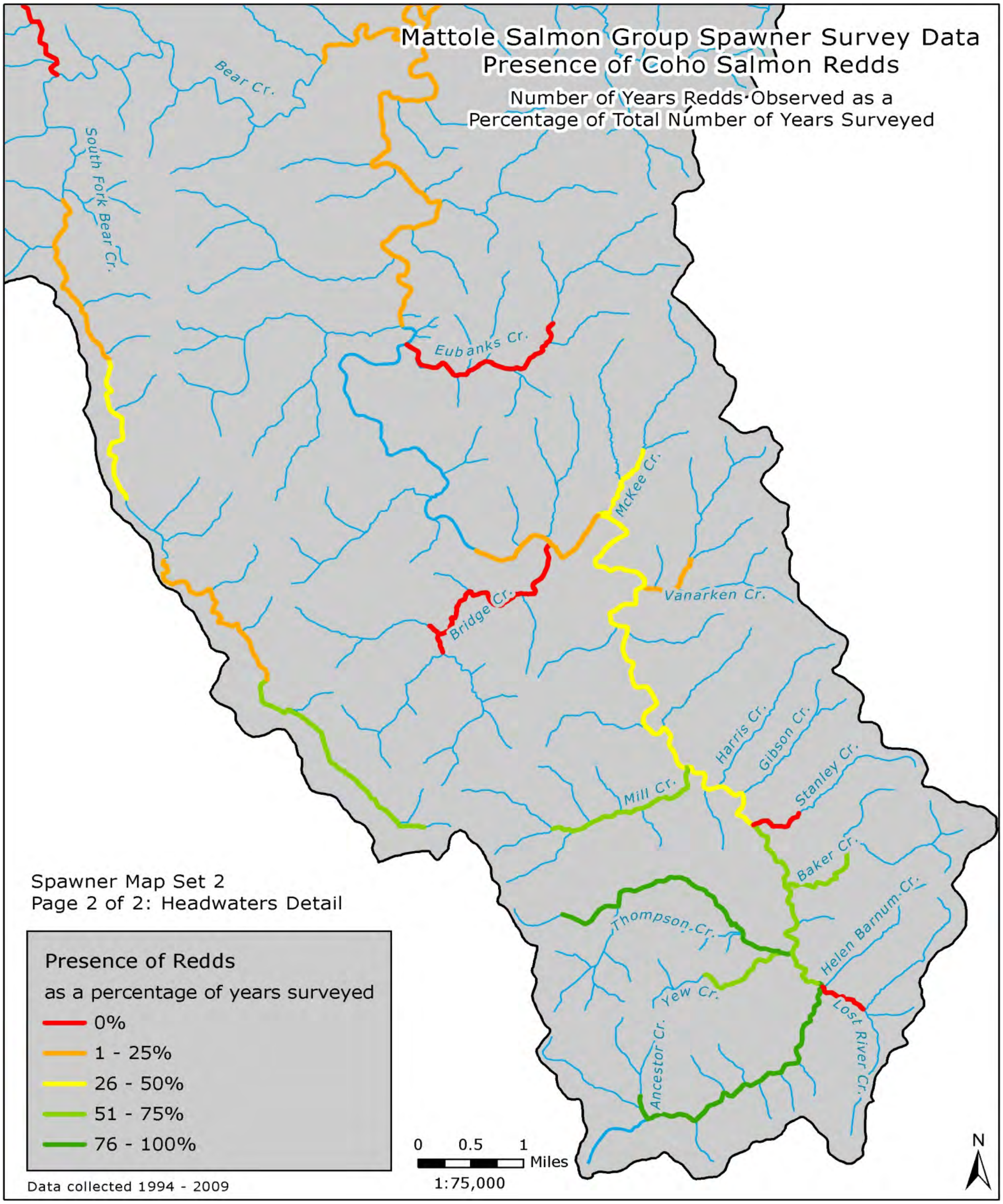


Figure 11. Presence of coho salmon redds as a percentage of years surveyed from upper Bear Creek (RM 42.8) to the headwaters (RM 63.0) in the Mattole River Watershed, MSG spawner surveys, 1994-95 through 2009-10 seasons.

Note: detail documents all reaches where percentage is greater than 25%.

Further examination of the data reveals the majority of spawning occurs in only a few selected tributaries and mainstem reaches (Figures 8-12). Of the 411 total redds observed since 1994, 114 were in the mainstem Mattole and 298 were in tributaries. Within the mainstem, 75% of all redds have been found within just two survey reaches: 10 in the reach from Stanley Creek (RM 57.1) to Mendocino County Bridge (RM 58.6), and 76 in the reach from Mendocino County Bridge to Philips/Hulse Creek (RM 60.5) (Figures 10 and 12). Of the 298 redds documented in tributaries, 98% were recorded in only five creeks: 187 in Thompson Creek (RM 58.4), 21 in Baker Creek (RM 57.6), 19 in Upper Mill Creek (RM 56.2), 10 in McKee Creek (RM 52.8), and 55 in South Fork Bear Creek (RM 42.8+5.0). Within these tributaries, the vast majority of spawning occurred in only two creeks – Thompson Creek (187; 63%) and South Fork Bear Creek, which contained 63% and 18%, respectively, of all redds documented in tributaries. The Thompson Creek drainage, including tributaries Danny's Creek (RM 58.4+2.2) and Yew Creek (58.4+0.13), has been the site of 45% of all redds documented in the Mattole since 1994. Figure 8 compares redd observations in all reaches where more than 20 redds have been observed since 1994.

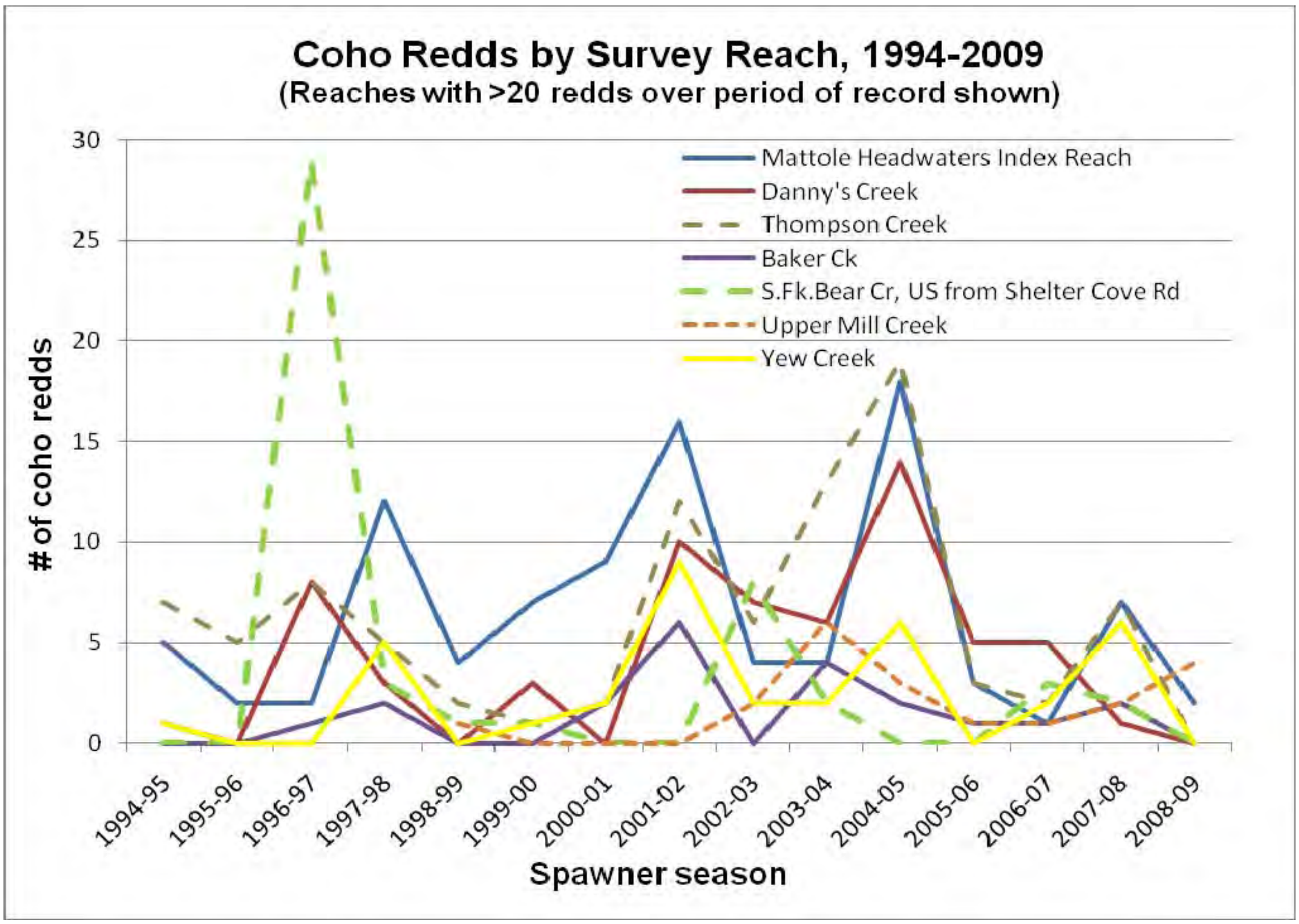


Figure 12. Redds observed per year in all reaches with more than 20 redds observed cumulatively from 1994-95 through 2008-09 seasons.

2. Juveniles

a. Data gaps

The MSG has conducted outmigrant trapping of juvenile salmonids (downstream migrant trapping, DSMT) in the lower mainstem Mattole River since 1985 (using a fyke net trap through 1996, and a 1.5 m rotary screw trap thereafter). From 1997-2004, outmigrant trapping was also conducted on Bear Creek at Ettersburg, and from 2001-2004 on the mainstem Mattole at Ettersburg. An outmigrant trap was also operated on Lower Mill Creek in 1992. Outmigrant trapping has been primarily focused on generating Chinook salmon outmigrant population estimates. Coho catches have varied dramatically year to year, in part due to high flows that inhibit the ability to consistently commence trapping early enough in the season. High flows can postpone trap placement until after the start of outmigration of coho salmon, or interrupt trapping in the middle of the season, and an unknown percentage of the population is not captured.

Summertime snorkel surveys to detect juvenile coho presence/absence are conducted in only a portion of the watershed, but do target the tributaries where coho presence has been most consistent and is considered most likely. Juvenile summertime distribution in un-surveyed streams and reaches is a data gap, as is our lack of understanding of juvenile and pre-smolt movement in the late fall and winter.

b. Abundance

Based on data compiled since 1992, numbers of outmigrants caught in the lower mainstem have ranged from 481 in 2006 to 0 in 1996, with a mean of 94 (Table 3). Numbers of trapped coho have varied widely and are highly dependent on commencement of trapping, days trapped, trap type, and trap location. Ninety-six percent of all outmigrant coho captured in lower mainstem traps have been 1+ smolts.

In all but one year of DSMT operation, mark-recapture efforts were not employed due to the low numbers of coho salmon caught in the trap, and therefore, no population estimate can be made. However, in 2006, a mark recapture study was undertaken due to the occurrence of higher coho capture numbers than in previous years. Coho smolts were captured in sufficient numbers to calculate trap efficiency for the first three weeks of trapping, and then Chinook efficiency estimate numbers were substituted for the remainder of the season. This led to a very rough outmigrant population estimate of 4,922 ± 2,510 (95% confidence interval) for coho salmon using the Carlson method of estimation (Carlson et al. 1998). This number was also compared to an alternate flow-based abundance index method of estimation that gave a population estimate of 3,275, which falls within the 95% confidence interval of the estimate generated using the Carlson method. These population abundance estimates are therefore credible, but are based on assumptions and are not the most scientifically desirable.

Table 3. Mattole River lower mainstem coho outmigrant DSMT data, 1992-2010.

Year	Young-of-the -Year (YOY)	1+	Total	Commencement of trapping	Number of days trap operated	Trap Location (RM)	Trap Type
1992	4	0	4	April 5	62	2.8	fyke net
1994	3	0	3	May 2	82	2.8	fyke net
1995	--	--	2	May 26	15	2.8	fyke net
1996	0	0	0	June 12	12	2.8	fyke net
1997	7	11	18	May 24	30	2.9	1.5m screw trap
1998	1	158	159	April 16	56	2.9	1.5m screw trap
1999	2	25	27	April 23	38	2.9	1.5m screw trap
2000	0	5	5	May 16	26	2.9	1.5m screw trap
2001	2	29	31	May 3	57	2.9	1.5m screw trap
2002	7	10	17	May 7	46	2.9	1.5m screw trap
2003	--	--	13	May 20	49	2.9	1.5m screw trap
2004*	2	17	71	May 4	35	2.9	1.5m screw trap
2005	16	53	69	May 13	36	3.9	1.5m screw trap
2006	4	477	481	May 3	58	3.9	1.5m screw trap
2007	0	218	218	Apr 9	64	3.9	1.5m screw trap
2008	0	322	322	Apr 10	72		1.5m screw trap
2009	3	215	218	Apr 24	57	3.9	1.5m screw trap
2010	0	3	3	April 21	92	3.9	1.5m screw trap

**In 2004, not all trapped fish were measured; "--" denotes data not available.*

Data from 2006-09 show that peak out-migration of coho in the Mattole varies from the end of April through the beginning of May (Figure 13). Because the date of trapping commencement varies from year to year, and rarely, if ever, is it possible to deploy the trap early enough in the season to catch the beginning of coho smolt outmigration, we used an exercise to compare year-to-year numbers while taking into account trapping effort. Figure 14 displays numbers of "potential" outmigrants per year compared to the number of coho juveniles actually caught. The "potential" catch was determined by multiplying the average number of fish caught per day when the trap was deployed by the total number of days from March 1 to June 15 (107 days). This standardized sampling period chosen (March 1 - June 15) is based on outmigrant timing in the Mattole and other watersheds.

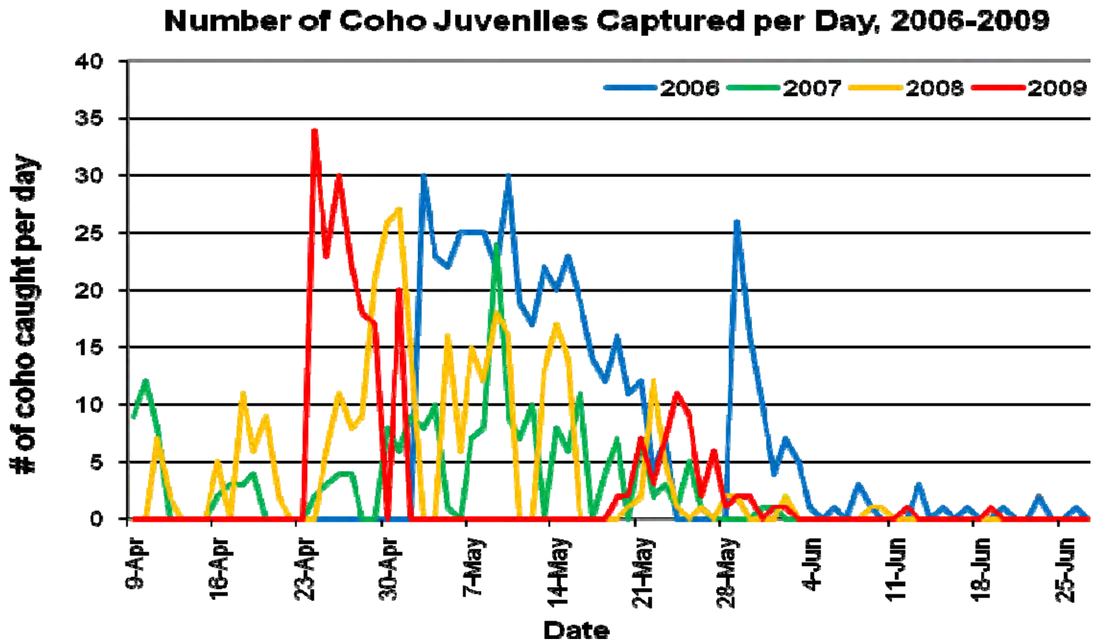


Figure 13. Numbers of coho salmon caught per day in lower mainstem Mattole River rotary screw trap (RM 3.9), 2006-09.
Note: since only three coho were caught in 2010, data from that year is not shown.

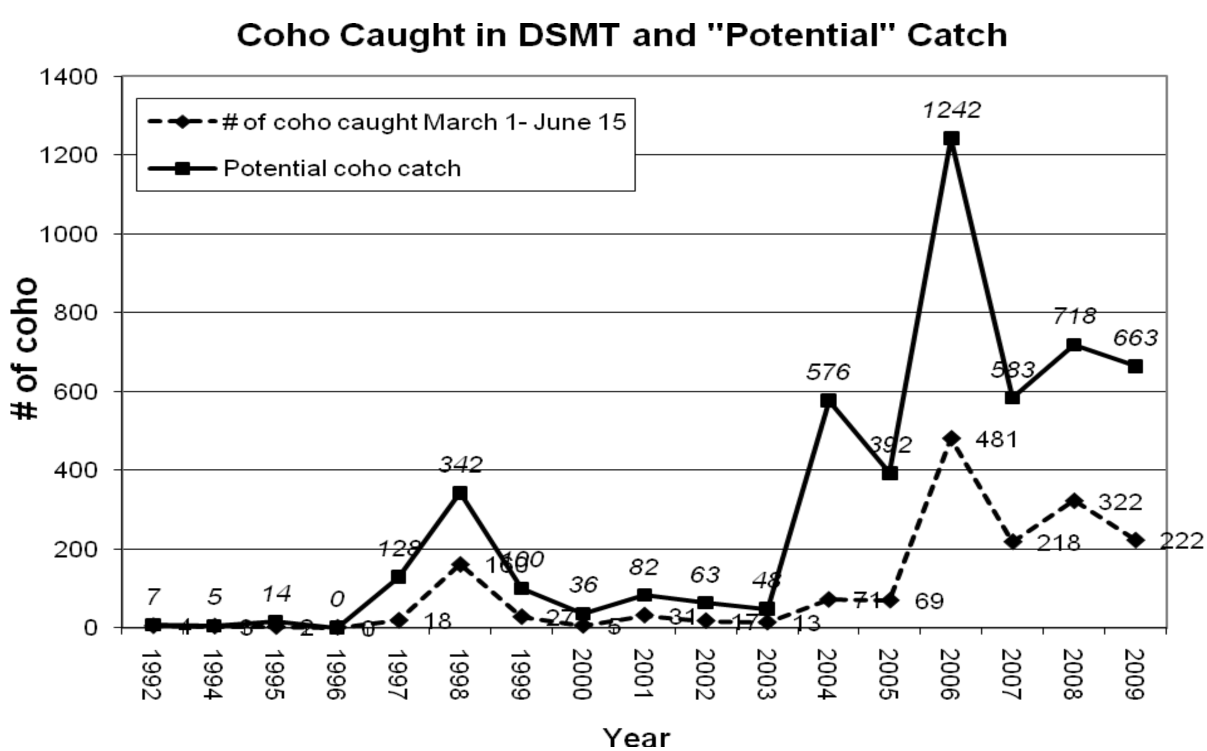


Figure 14. Numbers of coho caught in lower mainstem Mattole River DSMT from March 1 to June 15 each year vs. number of "potential" coho outmigrants for the same time period, 1992-2009.

Also for comparison, trap efficiencies calculated for Chinook salmon smolts for 2006-09 were used to produce a coho smolt population estimate (Figure 15). The method used for the Chinook population estimate is the Carlson method (Carlson et al. 1998). Each week a certain number of fish are marked and released upstream of the trap, and then recaptured fish are recorded in subsequent days of trapping. The total number of smolts captured is then multiplied by the percentage of marked Chinook recaptured. This method takes into account trap efficiency per week. To extrapolate this method to coho salmon, the number of coho smolts captured was multiplied by the percentage of marked Chinook recaptured. This method provides a rough population estimate of coho salmon, of uncertain validity.

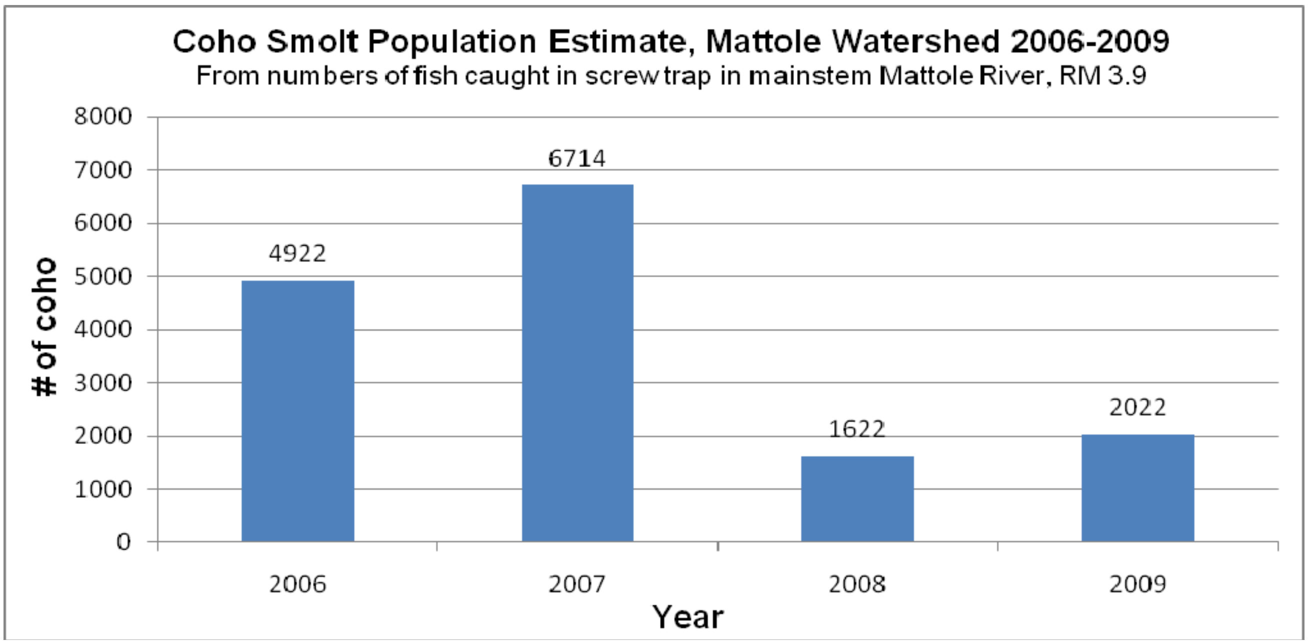


Figure 15. Coho smolt population estimate based on Chinook salmon trap efficiencies applied to coho captured in the Mattole River lower mainstem rotary screw trap, 2006-09.

In regard to outmigrant trapping efforts on Bear Creek at Ettersburg and the Mattole mainstem at Ettersburg, notably higher numbers of young-of-the-year (YOY) were captured some years at these locations. For example, in 1997, 35% of 293 coho juveniles caught in Bear Creek were YOY, and in 1998, 59% of the 29 coho captured were YOY. In Lower Mill Creek in 1992 (the only year a DSMT was operated), out of 20 coho juveniles recorded, 13 (65%) were YOY.

The abundant coho smolts and YOY captured in the 1997 Bear Creek DSMT could have been influenced by releases from MSG's rearing program. In the summer of 1984, 730 pre-smolts were released in the South Fork of Bear Creek (MSG 2000), and in the winter of 1996-1997 an unprecedented number of coho redds were tallied in South Fork Bear Creek (Figure 12, pg. 24). This spawning activity, whether the product of the released fish or not, would likely have generated a very large class of YOY, increasing the chance that a significant number of them would be swept out of their natal reach in the spring. In the summer of 1996, 2,550 pre-smolts were released in the North Fork of Bear Creek, which would have contributed to the large number of smolts captured in 1997 at the Bear

Creek trap. These documented occurrences in Bear Creek are the only incidence of anomalous coho abundance which could be correlated to the release of reared fish.

c. Distribution

MSG dive surveys have documented juvenile presence and distribution since 1991. These surveys have been generally conducted twice annually in early summer (May-June) and early fall (September-October) using the "10 pool" protocol (Preston et al. 2002).

In recent years, coho have been observed in fewer and fewer tributaries as a percentage of tributaries and tributary reaches surveyed (Figure 16). When considering all data since 1994, coho salmon have been observed in 40 tributary reaches, accounting for 63% of total tributary reaches surveyed. When only considering data since 2000, coho have been observed in 26 tributary reaches, accounting for 44% of those reaches surveyed. A widespread dive monitoring effort from 2007-09 found coho in only 13 tributary reaches, or only 30% of the reaches monitored (Figure 16). In 2010, observed coho juvenile distribution was the most restricted since annual dive summaries were initiated, with coho found in only two tributaries (consisting of four reaches) out of 21 tributaries (totaling 42 reaches) surveyed. Additionally, in 2010, only a single juvenile coho was observed in the upper mainstem Mattole during either spring or fall surveys.

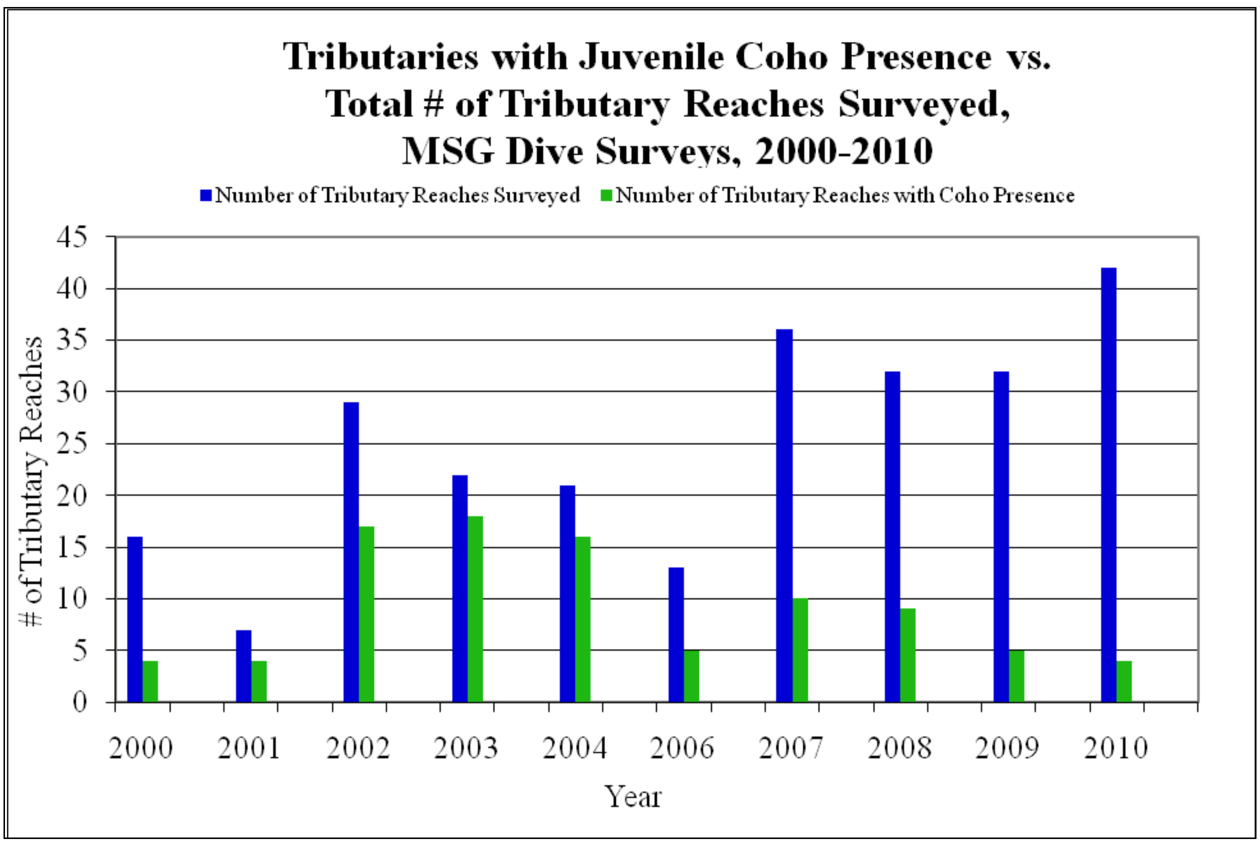


Figure 16. Tributaries with juvenile coho presence vs. total number of tributary reaches surveyed in the Mattole River Watershed, based on MSG snorkel surveys using the "10 pool" protocol, 2000-2010.

Recent surveys not only document the trend of fewer and fewer tributaries with coho presence, but also document a shrinking geographical distribution on a watershed-wide scale. Surveys since 1994 have documented coho in a total of 17 tributaries downstream of RM 52.1 (Bridge Creek confluence). That number decreases to seven tributaries since 2000, and since 2007, coho presence has been observed in only four tributaries downstream of RM 52.1, despite expanded survey efforts (Figure 16). In 2010, no coho were observed downstream of RM 52.1.

Table 4. Comparison of coho observations in spring and fall, both below and above RM 52.1 in the Mattole River Watershed, 2000-2010.

Location	**Numbers of Coho Observed**		**% Decrease in Numbers from Spring to Fall**
	Spring	**Fall**	
Tributaries below RM 52.1	56	8	86%
Tributaries above RM 52.1	3,661	1,445	61%
Tributaries above RM 52, not including 2002 data	1,878	1,357	28%

Only 64 juvenile coho in total have been observed downstream of RM 52.1 since 2000 (Table 4, Figure 17). The greatest number of juvenile coho observed at any site at any one time downstream of RM 52.1 was 12 individuals (Mattole estuary, spring 2001). Juvenile coho abundance is greater and more consistent in tributaries upstream of RM 52.1 than downstream of this location (Table 4, Figures 17-20).

Since 2000, juvenile coho have been observed in both the spring and fall every year above RM 52.1. Below this location, however, the majority (87.5%) of coho documented have been seen in the spring. Table 4 displays spring and fall observations of coho salmon in upriver and downriver tributaries, along with the percentage decrease from spring to fall for 2000-10. In 2002, the highest number of juvenile coho were observed in the watershed (1,783) during any single survey season. This same year, the greatest decrease from spring to fall was documented, with numbers declining 95% from spring to fall. An extreme drought occurred in 2002, and significant portions of the upper 11 miles of the mainstem dried for the first time in 30 years. The subsequent death of thousands of juvenile salmonids in the headwaters was most likely responsible for the low observations in the fall. Removing observations from 2002, the decrease in individuals observed from spring to fall from 2000-01 and 2003-10 in upriver tributaries is 28%.

In 2009, coho were observed in both spring and fall in only two tributaries, Thompson Creek (RM 58.4) and Yew Creek (RM 58.4+0.15), a tributary to Thompson. Thompson and Yew Creeks accounted for 65% of all coho observed in 2009, 53% in 2008, and 71% in 2007. In 2010 alone, 51% of total juvenile coho observed were within the Thompson Creek and the North Fork of Thompson Creek (39 of 77 observations).

Aside from Thompson and Yew Creeks, the tributary with the most consistent coho observations in spring and fall is Ancestor Creek. Although Ancestor Creek counts have been lower than those of Thompson and Yew, juvenile coho have been present in fall in each of the past four years. Ancestor Creek was the only tributary in addition to Thompson Creek and the North Fork of Thompson Creek where coho were observed in 2010. Baker Creek and Upper Mill Creek are also two tributaries with consistent coho presence over the years in either spring or fall, but rarely during both seasons.

Over the years surveyed, numbers throughout the watershed have declined significantly at all locations. The total number of coho observed during 2010 spring and fall dives was 77 – the lowest on record. Total numbers of juveniles observed during 2009 dives (132) were 69% and 64% lower than in 2008 (432) and 2007 (368), respectively. The total number of coho in tributaries upstream of RM 52.1 has declined by 85% from 2002-04 (4,721) to 2007-09 (728)..

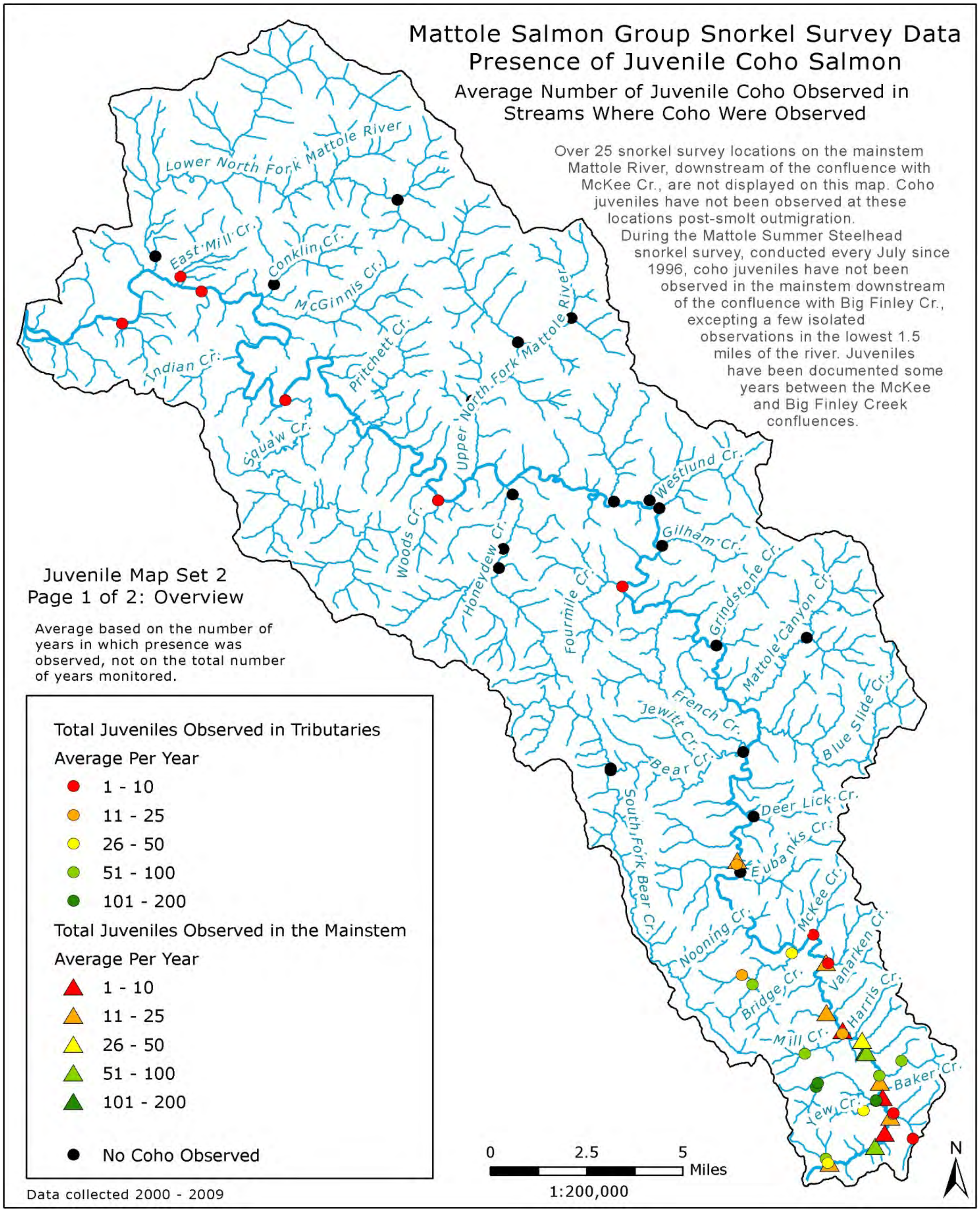


Figure 17. Average number of juvenile coho observed in tributaries where coho were observed in the Mattole River Watershed, MSG snorkel survey data, 2000-09.

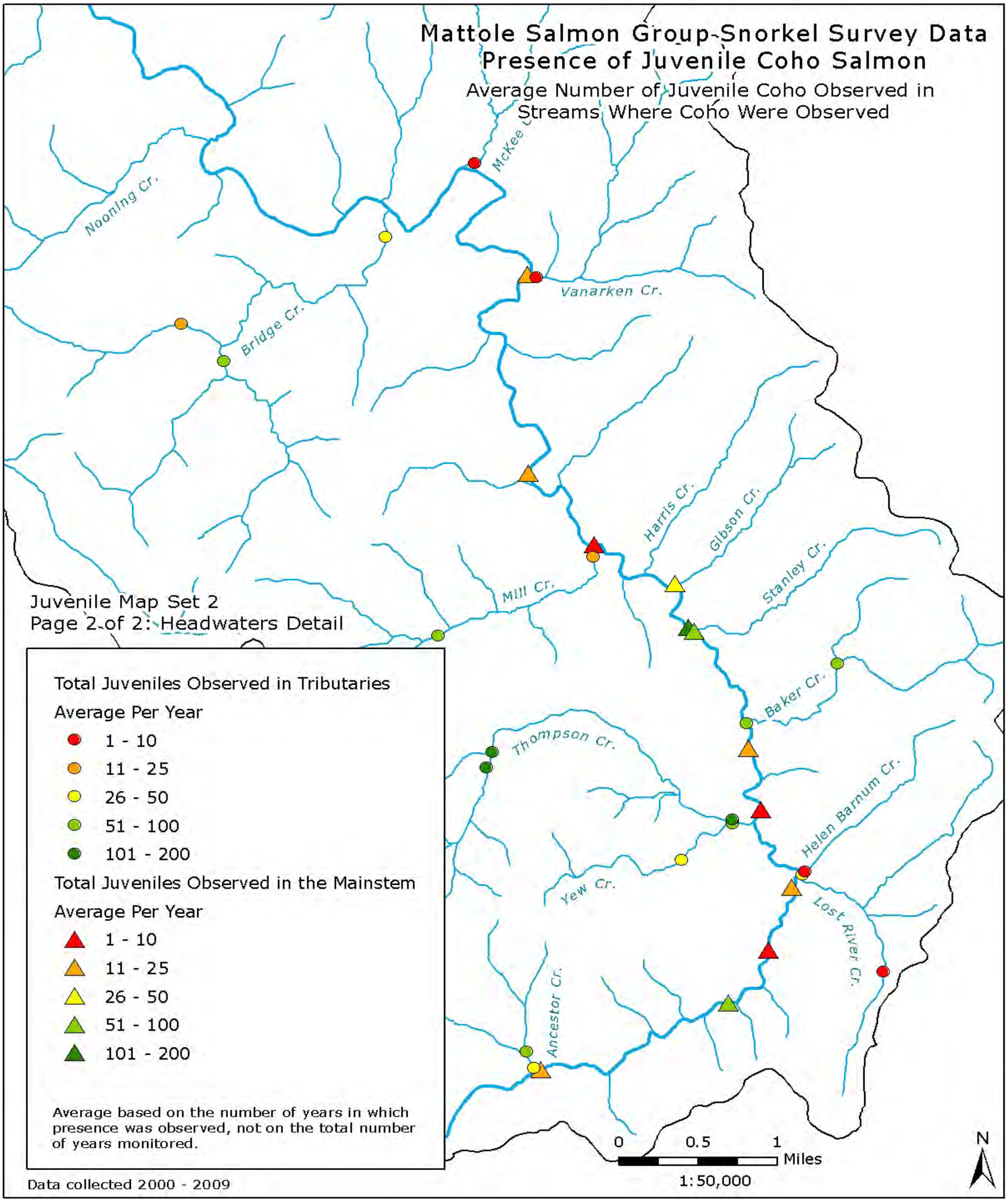


Figure 18. Mattole headwaters detail of average number of coho juveniles observed in tributaries where coho were observed in the Mattole River Watershed, MSG snorkel survey data, 2000-09.
Note: detail encompasses all locations in the watershed where more than 25 coho were observed on average.

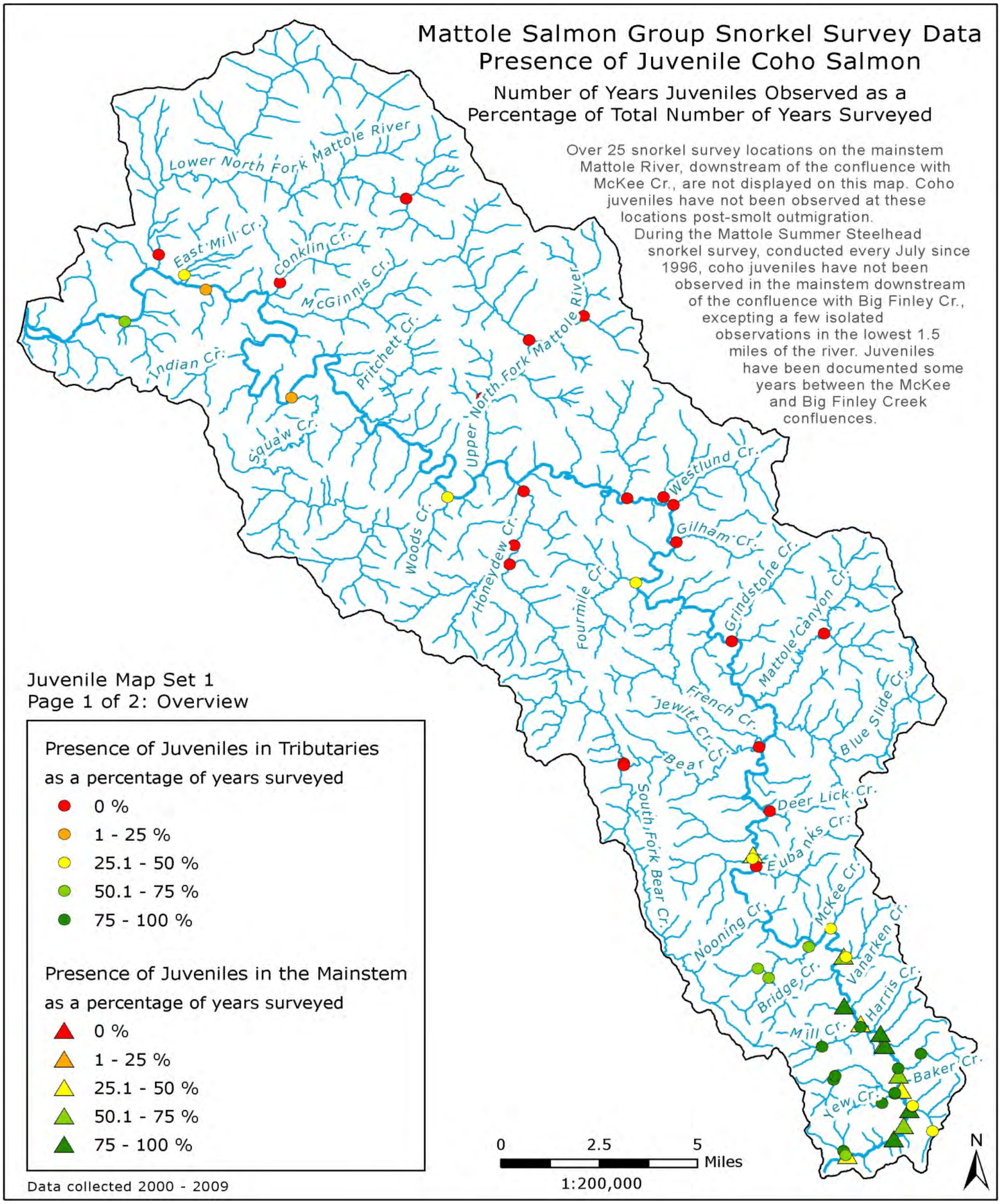


Figure 19. Number of years juvenile coho observed as a percentage of years surveyed in the Mattole River Watershed, MSG snorkel survey data, 2000-09.

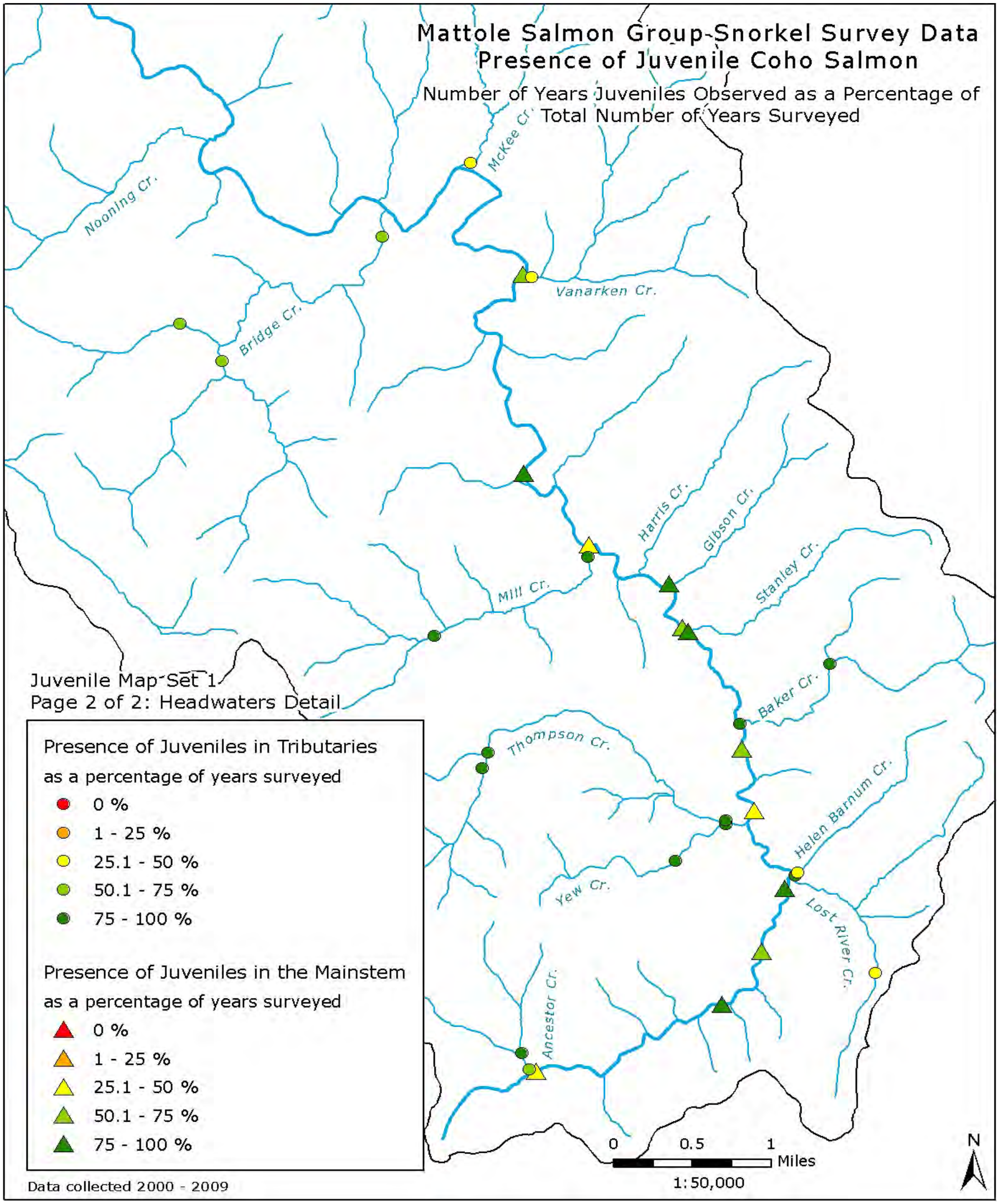


Figure 20. Mattole headwaters detail of number of years juvenile coho observed as a percentage of years surveyed in the Mattole River Watershed, MSG snorkel survey data 2000-09.

Note: detail documents all areas where coho were observed in over 50% of the years surveyed.

In addition to greater distribution and abundance of coho upstream of RM 52.1 than lower in the mainstem, the headwaters area is also the only place we have observed coho of a larger size class (>100 mm) during summer snorkel surveys since 2001, with an exception in 2004. Table 5 compares numbers and locations of 100-200 mm coho salmon from 2009-07 and 2004-02. These years are used for comparison due to similar survey effort.

Table 5. Locations of coho salmon >100 mm observed via dive observation in the Mattole River Watershed, 2009-07 and 2004-02.

Location	**River Mile**	**2009**		**2008**		**2007**		**2004**		**2003**		**2002**	
		Spring	**Fall**	**Spring**	**Fall**	**Spring**	**Fall**	**Spring**	**Fall**	**Spring**	**Fall**	**Spring**	**Fall**
Mainstem RM 60.95	60.95	N/A	N/A	N/A	N/A	N/A	N/A	0	2	0	0	0	0
McNasty Creek, trib. of Ancestor Creek	60.8+ 0.15+ 0.05	N/A	N/A	N/A	N/A	N/A	N/A	7	1	0	0	0	0
Ancestor Creek	60.8	0	0	0	14	0	0	29	13	0	0	0	0
Mainstem RM 59.6	59.6	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	3	0
Mainstem RM 58.9	58.9	0	0	0	20	0	0	N/A	N/A	N/A	N/A	N/A	N/A
Yew Creek (upper)	58.4+ 0.13+ 0.4	N/A	N/A	N/A	N/A	N/A	N/A	6	2	0	0	0	0
Yew Creek (lower)	58.4+ 0.13+ 0.1	0	0	0	15	0	24	0	2	0	0	0	0
Thompson Creek (upper)	58.4+ 2.2	N/A	N/A	N/A	N/A	N/A	N/A	0	0	0	0	3	0
Thompson Creek (lower)	58.4+ 0.15	1	1	0	98	0	24	41	5	0	0	11	0
Baker Creek (upper)	57.6+ 0.95	N/A	N/A	N/A	N/A	N/A	N/A	0	2	1	0	0	0
Mainstem RM 56.9	56.9	0	0	0	0	0	0	0	0	11	0	0	0
Upper Mill Creek (upper)	56.2+ 1.4	N/A	N/A	N/A	N/A	N/A	N/A	0	1	0	0	0	0
Upper Mill Creek (lower)	56.2+ 0.1	0	0	0	15	0	0	0	0	0	0	0	0
Upper Bridge Creek/"Rob-ertson Creek"	52.1+ 2.1	N/A	N/A	N/A	N/A	N/A	N/A	0	0	0	0	1	0
Mainstem RM 3.3	3.3	0	0	0	0	0	0	2	0	0	0	0	0
Mainstem RM 2.9	2.9	0	0	0	0	0	0	10	0	0	0	0	0
Total		**1**	**1**	**0**	**162**	**0**	**48**	**95**	**28**	**12**	**0**	**18**	**0**

Juvenile coho abundance and distribution, like spawning activity, appears to be heavily concentrated in a handful of stream reaches in the Mattole headwaters, and to a lesser extent in the Bear Creek drainage. It seems likely that most of the fish observed in tributaries below RM 52.1 are non-natal juveniles, redistributed or displaced by high spring flows. This conclusion is based on the extremely few numbers of fish observed in each stream downstream of RM 52.1, and the lack of documented spawning activity in these reaches. Electro-fishing conducted by CDFG has also detected very low numbers of juveniles (<10) in some years in lower river tributaries (Table 1; Jong et al. no date, M. Gilroy pers. comm. July 7, 2009).

III. Mattole Limiting Factors

A. Adult Migration and Spawning

1. Habitat Requirements

In smaller coastal streams such as the Mattole, entry into freshwater often occurs in the fall following the first storm of sufficient strength to breach the sandbar at the river mouth. Successful immigration is a function of temperature, stream depth, stream velocity, dissolved oxygen (DO), and stream barriers. As for stream barriers, fall height to pool depth ratios of 1:1.25 are considered passable barriers so long as the barrier height does not exceed 10 feet. Deep pools are therefore necessary for migrating adults to clear barriers. Moderate debris barriers also provide cover for coho and allow for the formation of pools that provide the fish with areas to rest (Bjornn and Reiser 1991).

Spawning is highly dependent on water temperatures with a narrow optimum range between 4.4-9.4^{o}C (40-49^{o}F). The average space needed for spawning coho pairs is 39 ft^2 and the minimum water depth necessary for redd survival is 0.5 ft (Bjornn and Reiser 1991). Ideal flow velocities lie between 1-3 ft/s and substrate sizes between 0.5-4 inches in diameter, with a low degree of embeddedness (Bjornn and Reiser 1991). Spawning typically takes place at the pool to riffle transition (Moyle et al. 2008).

Finding a mate within the spawning habitat is also critical to spawning success. Below a threshold population density, individuals may not be able to find each other and spawn, resulting in a population crash. Reduction in population growth rate due to lack of mating opportunities is one of the Allee effects known to affect salmon at low densities (Kramer et al. 2009). Allee effects result in depensation, or lower per capita productivity at low densities. Depensation due to inability to find a mate has been correlated with a spawner density of fewer than one female coho salmon per kilometer of river (Barrowman et al. 2003).

2. Habitat Conditions

With no complete mainstem migration barriers, and adequate fall height to pool depth ratios, Mattole coho have access to the entirety of the mainstem, as well as headwaters tributaries, except during periods of very low winter streamflows. Observed spawning activity is currently primarily limited to these specific upper mainstem and headwaters tributary reaches (Figures 8-11, pgs 20-23).

The timing and magnitude of flows can have a major effect on spawning location and, ultimately, the suitability of spawning habitat utilized. In years without adequate rainfall, coho adults may spawn lower in the river system than in years when they are able to access the preferred upper mainstem and headwaters tributaries spawning reaches. Presumably, in years when streamflows are insufficient to allow access to these headwaters reaches (such as occurred to some extent in 1999-00 and 2000-01) redds are more susceptible to scour due to higher shear stress, and to entombment by fine sediment in lower river reaches. In general, recent measurements of the suitability of potential spawning substrate in tributaries and in the upper Mattole mainstem found favorable conditions (Table 6), especially in most of the reaches where spawning. has been documented in the past decade (primarily the Southern Subbasin).

Table 6. Cobble Embeddedness and % Pool Tail Fines <2 mm measured in 81 Mattole stream reaches*, compared to target values from the *CCC Coho Salmon ESU Draft Recovery Plan* (NMFS 2010) and the Federal Aquatic and Riparian Effectiveness Monitoring Program, Franciscan Province (AREMP 2005).

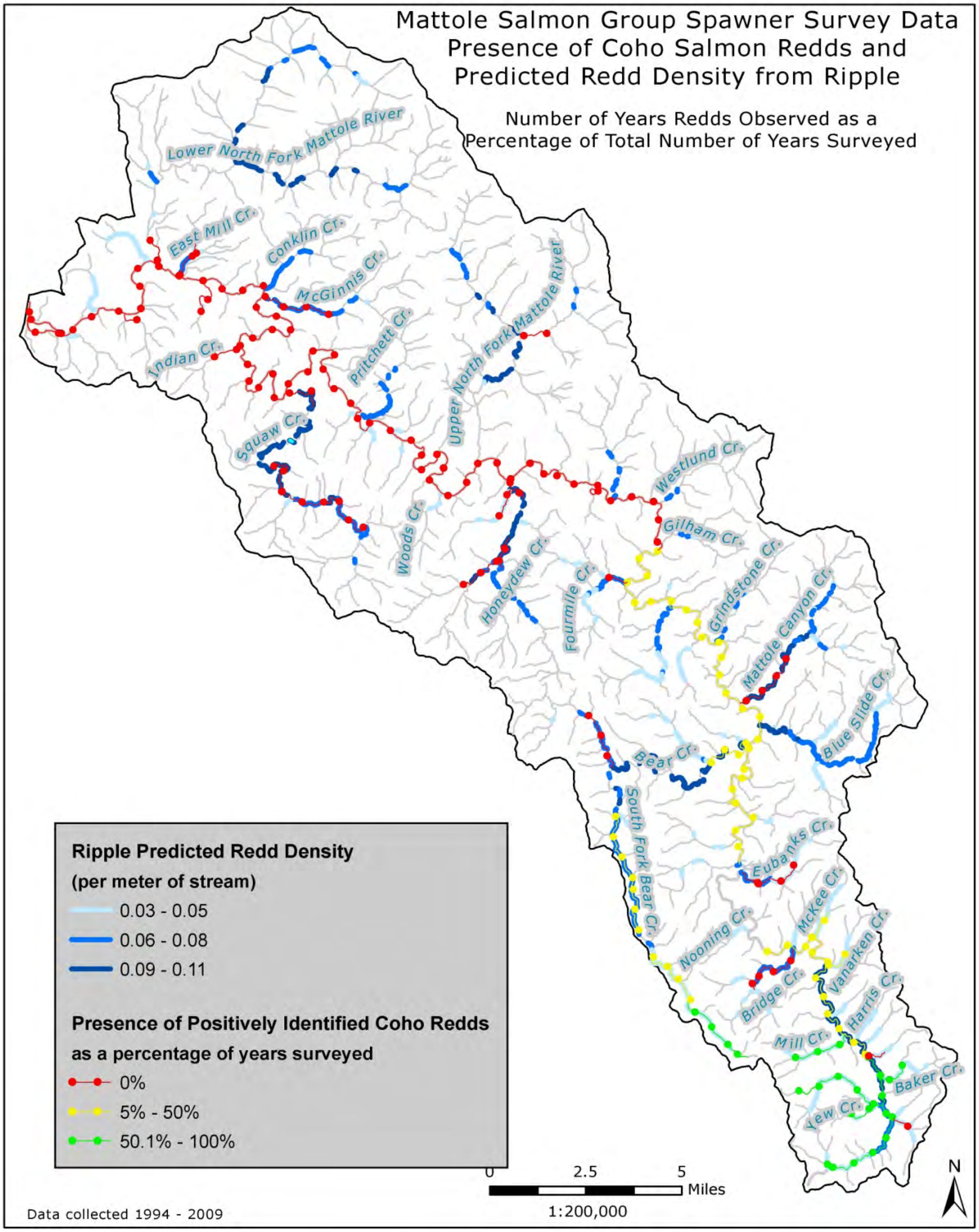
Rating, Criteria, and % of Surveyed Reaches in Each Category			
	Poor (% of reaches)	**Fair (% of reaches)**	**Good (% of reaches)**
Cobble Embeddedness at pool tails	**<25% of cobbles <50% embedded**	**25%-50% of cobbles <50% embedded**	**>50% of cobbles <50% embedded**
All reaches (81 reaches)	9	12	79
Eastern Subbasin (23)	17	13	69
Northern Subbasin (14)	21	43	36
Southern Subbasin (21)	0	0	100
Western Subbasin (23)	0	4	96
% of surface substrate <2mm at pool tails	**>30% surface substrate <2mm**	**10%-30% of surface substrate <2mm**	**<10% surface substrate <2mm**
All reaches (81 reaches)	10	36	54
Eastern Subbasin (23)	4	60	34
Northern Subbasin (14)	50	35	14
Southern Subbasin (21)	0	10	90
Western Subbasin (23)	0	35	65

**Data from Mattole Restoration Council (MRC) surveys conducted in 2005 and 2007 (MRC 2008). Length of sampled reaches is 20 times bankfull width.*

Wintertime temperatures at the U.S. Geological Survey (USGS) Ettersburg gauge (USGS 2010) show water temperatures mostly within the range suitable for spawning as do temperatures recorded with handheld thermometers at the start and end of spawning ground surveys.

Quantitative data on wintertime DO levels is lacking, but the MSG believes it is safe to assume DO is not limiting spawning based on existing knowledge of summertime DO levels and trends. MSG dissolved oxygen monitoring during the summer months has found lethal DO levels exclusively in correlation with low flows that lead to disconnected pools and dry reaches. Based on highly seasonal winter rainfall and resulting winter flows in the Mattole, dissolved oxygen likely remains suitable throughout the spawning season.

Figure 21 compares observed coho redds with predicted redd density from the Stillwater Sciences RIPPLE model. Actual redd observations are confined to a much smaller portion of the watershed than predicted by the model. As shown in Table 6, embeddedness and instream fine sediment levels are greater in the Northern and Eastern Subbasins of the watershed, where much of the predicted but seemingly unoccupied spawning habitat is located. These subbasins, however, have higher natural rates of sediment loading, more mass wasting, and a greater fines-rich lithology than the Western and Southern Subbasins. These natural conditions combined with the effects of past land use have left many of the streams in the northern two-thirds of the watershed which are shown as *potential* spawning habitat with considerably degraded habitat conditions in reality (see Table 11, pgs. 64-65).



Mattole Restoration Council GIS | 10/20/10 | \mcms\msg\cohorecovery_spawnerpresRipple.jpg

Figure 21. Number of years redds observed as a percentage of total number of years surveyed, shown in comparison with RIPPLE-predicted redd density.

In some of these streams, however, sediment-related conditions seem to have markedly improved in the last decade, perhaps to the degree where they could successfully be utilized by coho. Despite these improvements, the probability for straying spawners to re-colonize these recovering habitats is low, due to the very low numbers of adult returns. Additionally, even with declining sediment loads, many of the streams shown as potential spawning habitat in Figure 21, with gradients of ~1-4% in confined valleys require abundant instream wood to force pool-riffle morphology and create localized areas of deposition of spawnable gravels (Montgomery and Buffington 1998). Past land-use has removed the instream wood and the sources of future wood in the near-term.

Adult abundance observed in the Mattole during the 2008-09 and 2009-10 seasons indicates the adult population is well below the one female coho per kilometer threshold considered to lead to depensation in other coho salmon populations (Barrowman et al. 2003). In the Mattole River Watershed, this value would be approximately 101 adult female coho, which is significantly higher than the total combined number of adult females recorded in the Mattole over the past 15 years. Based on the current observed population of Mattole coho spawners, the Allee effect caused by difficulty in finding a mate may represent a more critical limiting factor for adults than any other habitat condition.

3. Data Gaps

Although harvest is closed for all salmonid species in the Mattole, poaching does occur. Beginning January 1 every year, a catch-and-release fishery is open for all species, however the timing of the fishing season is focused on steelhead. Despite this restriction, reports of individuals fishing in lower river pools are common prior to the season opening, when salmon are unable to move further upstream due to low flows. Additional reports and rumors of fish harvest are not uncommon every season, beginning in October and continuing through March. We do not know the extent of coho mortality from poaching and incidental catch in the Mattole River Watershed.

4. Research from Other Watersheds

Coho salmon populations have been shown to exhibit an Allee affect (Chen et al. 2002). Chen et al. (2002) developed a model to predict extinction probability in fish stocks and found the Allee effect parameter to be statistically significant for coho within their study watershed in British Columbia. Their model used spawner density as the parameter defining the Allee effect. Kramer et al. (2009) completed a literature review of evidence of the Allee effect, and found evidence of a critical spawner density due to the Allee effect. Furthermore, Kramer et al. (2009) found evidence of mate limitation as a mechanism causing the Allee effect.

Difficulty in finding a mate can have several mechanisms negatively impacting spawning success. Low fish density can lead to pre-spawning mortality if the density was so low that individuals were unable to find a mate before dying. Failure to find a may mate also increase stress levels over time, affecting spawning success (Greene and Guilbault 2008). Disparities in sex ratios of few remaining individuals can lead to an Allee effect in mating opportunities and result in more intense aggression at very low spawning densities (Parenskiy 1990).

Another Allee effect observed in salmon at low population densities is avoidance of high-quality habitat in preference for colonized reaches. Individuals are forced to choose habitat based on mate availability rather than quality. This can undermine individual success in spawning and, over time, lead to population decreases (Greene and Guilbault 2008).

5. Summary

Due to the low numbers of coho entering the watershed and low findings of redd superimposition, availability of spawning and migration habitat is not considered a factor limiting the survival of coho salmon in the Mattole at this point in time. However, possible factors limiting migration and spawning success include flow (rainfall timing), poaching, and finding a mate.

Flow and rainfall timing no doubt affect the ability of Mattole coho to access optimal spawning reaches. Although these factors cannot be controlled, they warrant further investigation to more precisely determine the extent of their impact on coho spawning. Although we know poaching does occur, the extent to which poaching limits successful spawning is unknown. Due to the small numbers of returning adults each year, the poaching of even one fish could significantly affect the population.

With only three adult coho documented during 2009-10 spawner surveys, the Allee effect is a serious threat to the Mattole population. The difficulty of finding a mate is perhaps the most limiting factor for adult coho in the Mattole, especially considering the unlikely possibility of strays immigrating to this system, given its relative isolation from other watersheds with robust coho populations. The Allee effect leads to stock depensation, whereby a decrease in the adult/breeding population leads to reduced survival and production of eggs or offspring.

B. Egg Incubation and Alevin Emergence

1. Habitat Requirements

Water circulation through stream gravels is a vital factor that impacts the development of coho redds. Flows of 0.3-1ft/s are necessary to carry enough oxygen and flush out waste among salmonid embryos. The temperature range considered ideal for embryo development is 4.4-12.8^{o}C (40-55^{o}F), with faster growth rates in the upper portion of that range. The availability of oxygen is important to incubation success and requires DO levels greater than 8 mg/L and concurrently low levels of fine sediments. Fine sediment in spawning gravels decreases water circulation and survival and emergence of eggs and alevins. Sediment less than 0.85 mm in diameter is often considered to have the greatest deleterious effect (McNeil and Ahnell 1964), but larger particles are known to have negative impacts as well. Particles less than 6.4 mm can potentially prevent emergence of fry by infiltrating redds and forming a layer on the stream gravels (Lisle 1989). Substrate composed of greater than 30% fines <6.4 mm in diameter has been documented to reduce salmonid emergence and survival by 50% (Kondolf 2000). Shading from riparian vegetation and large substrate particles provide ideal incubation environments that help maintain adequate temperature, oxygen levels, and sediment levels (Bjornn and Reiser 1991).

2. Habitat Conditions

Conditions for egg incubation and alevin emergence in the Mattole appear largely suitable in streams with commonly observed coho spawning activity within the past decade. Winter and spring temperatures in the mainstem and other areas where coho spawning has been observed fall within the 4.4-12.8°C range considered favorable for egg incubation and emergence. As mentioned previously (section III.A.2), DO levels are believed to be suitable during the winter based on adequate summer DO levels in the watershed, except when pools are disconnected.

Late or weak winter rains can affect the location of spawning by trapping adults in the middle or lower mainstem. Redds positioned in "suboptimal" locations in the mainstem Mattole may be more susceptible to scour and fine sediment deposition than those in smaller streams in the headwaters with lower sediment loads. In regards to scour, it appears unlikely that this is a major factor responsible for recent declines of coho salmon in the Mattole, as there have been only two instances in the past decade when flows measured at the USGS Petrolia gauge exceeded bankfull stage (~31,000 cfs).

As noted in section III.A.2, substrate conditions appear to be generally favorable for spawning, incubation, and alevin emergence (Table 6), with low levels of embeddedness and fine sediment in reaches where coho spawning is observed, such as the Southern Subbasin. Figure 22 shows the percent change of surveyed reaches in each of three cobble embeddedness categories from mid-1990s to 2005 and 2007. While reach selection and spatial extent differed between the 1990s and more recent surveys, the measurement method was identical, and it is clear there is a much larger percentage of reaches with favorable levels of embeddedness in more recent surveys (with the exception of streams in the Northern subbasin). This is consistent with the observations of many long-time restoration workers in the watershed, who have noted improvements in instream sediment conditions in the last decade.

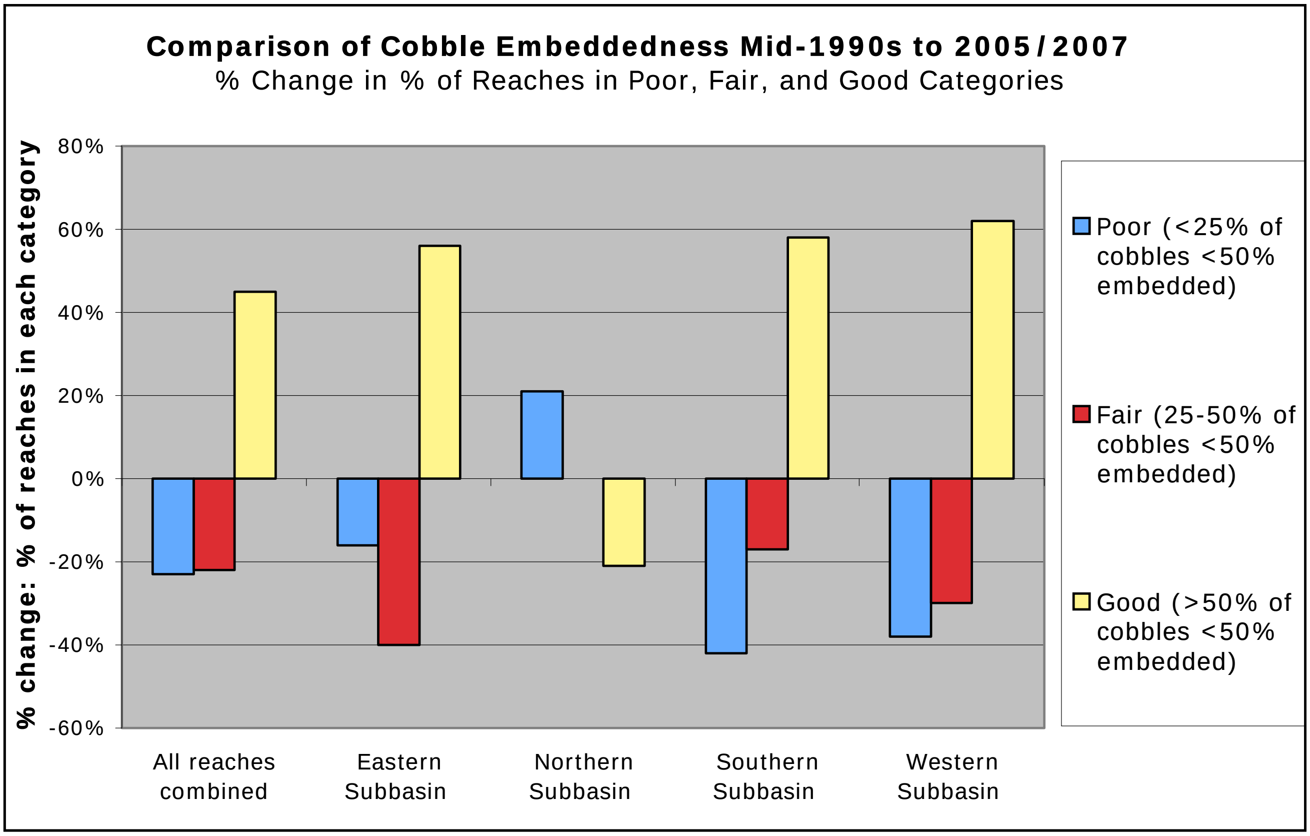


Figure 22. Comparison of cobble embeddedness ratings by subbasin, mid-1990s to 2005-2007.

Category definition from the CCC Coho Salmon ESU Draft Recovery Plan *(NMFS 2010). Mid-1990s data from CDFG surveys (Downie et al 2003), 2005 and 2007 data from MRC surveys (MRC 2008).*

3. Data Gaps

No Mattole-specific data exist on egg incubation and alevin emergence success. Survival of coho eggs and emergence downstream of the headwaters is presumed to be poorer due to greater embeddedness, more severe flows, and increased exposure to turbidity, but the extent to which these directly affect incubation and emergence is unknown in the Mattole. Also unknown is the extent of predation on eggs and alevins.

4. Research from Other Watersheds

Generally speaking, redd scour and a variety of deleterious effects due to excessive fine sediment are the factors most often cited as having negative effects on coho incubation success (Lestelle 2007). However, our review of relevant literature found little evidence for redd scour or entombment as an important source of mortality for coho populations, with the possible exception being years with very high flows, that far exceed bankfull capacity (Stillwater Sciences 2008). The ability of a single successful redd to fully seed a considerable reach of stream with juveniles seems to ensure that redd success would need to be very poor in order for it to be a primary factor limiting the population. Decreasing sediment loads and the coarsening of the channel should decrease the chance of scour or entombment, as should increasing channel roughness and reductions in localized shear stress from increases in stable instream wood (Woodsmith and Swanson 1997).

Lower-river spawning and/or premature downstream displacement of YOY could potentially reduce survival of Mattole coho by redistributing early emergents to less favorable and greater velocity habitats lower in the river system. Both energetic demands at higher flows and exposure to greater embeddedness downstream would result in decreased size of juveniles. Arthaud et al. (2010) studied relationships between streamflow and productivity for Chinook salmon across their entire life cycle in two systems, one with a natural hydrograph, and one with intensive irrigation. Their study indicated early-rearing flow was strongly related to adult return rate primarily through egg-outmigrant productivity.

In regards to embeddedness, Bolliet et al. (2005) studied the effects of embedded substrate on juvenile salmonids and suggested embeddedness resulted in decreased habitat carrying capacity, and led to poorer condition and smaller size of emergents. They found embedded substrate contributed to decreased overall size and health of the fish, in addition to increased heterogeneity in fish size. In the Mattole, embeddedness is more prominent in the lower river than in the headwaters. Poorer survival for emergents may be increased if adults are limited by low flows to spawning in reaches lower in the watershed.

While the negative effects of excessive fine sediment on spawning and alevin emergence are clear, there is also evidence from outside the Mattole that habitat conditions relating to this life stage are currently more suitable than habitat for other life stages. In the Central California Coast (CCC) coho ESU, conditions for spawning and alevin emergence are considered to be in the better than for any other life stage (NMFS 2010).

Exposure to predation may also be influenced by the Allee effect. Greene and Giulbault (2008) hypothesize high egg density in a spawning habitat might reduce an individual egg's risk of predation. Conversely, at low densities, individual eggs face a greater risk of predation. With so few redds observed in the Mattole over the past several winters, the effects of egg predation could potentially represent a major limit to survival due to the low number of individual eggs involved.

5. Summary

Data and observation indicate winter temperatures, dissolved oxygen levels, and substrate conditions seem to be suitable in reaches where coho spawning has been observed, and in most other potential spawning reaches to allow successful incubation and emergence of coho. Given the low number of redds, the Allee affect may also play a role in egg and alevin survival. Based on the available habitat data, however, we feel that habitat conditions for egg incubation and alevin emergence are not currently a primary factor limiting coho abundance in the Mattole River Watershed.

C. Fry and Juvenile Winter Rearing

1. Habitat Requirements

After emerging from the gravel, coho fry seek out shallow water and low-velocity conditions, often along channel margins (Lestelle 2007, Moyle et al. 2008). After sufficient growth, fry will venture out to areas protected from high velocity stream currents in the winter season, such as backwaters, side channels, small creeks, and other slow water habitats. Coho 1+ juveniles also show an affinity for low-velocity habitats. In many California streams, winter is the time of most rapid growth for juvenile coho (Moyle et al. 2008). Refuge from high and turbid stormflows is essential, and flow refuge created by instream wood, backwater pools, clear and small tributaries, side channels, and beaver ponds can provide adequate winter rearing sites (CDFG 2002, Lestelle 2007, Moyle et al. 2008, Sutton and Soto 2010). Unlike steelhead juveniles, coho appear to rarely use large substrate as cover (Lestelle 2007).

2. Habitat Conditions

A lack of instream habitat complexity throughout the watershed, as well as chronic turbidity in the lower river, are factors presumably affecting coho salmon winter rearing success in the Mattole.

Slack-water habitats are rare throughout the watershed. Many stream reaches are characterized by channel incision, disconnected floodplains, lack of off-channel habitat, and lack of instream wood. This current state of affairs is due largely to pre-Forest Practices Act timber harvest in riparian zones throughout much of the watershed, coupled with widespread removal of wood from stream channels from the 1950s-1980s (the product of concerns about the effects of instream wood on fish passage). Removal across the North Coast was conducted by private landowners, state agencies, and timber companies (who were in many cases complying with the law by doing so) (Wooster 2000). Table 7 displays volumes of wood removed by the California Conservation Corps from 16 Mattole streams in the 1980s. Some of the volumes removed are substantial, and appear to be far more wood than exists in those streams today.

Table 7. Volumes of instream wood removed from 16 streams in the Mattole River Watershed by California Conservation Corps crews, 1980-88.*

Stream Name	Date of last recorded cleaning	Cumulative miles cleaned	Total cords removed (128 ft^3/cord)	ft^3 of wood /100 ft of stream removed	Estimated number of 2' x 40' logs	# of key[†] pieces/100 ft of stream removed	Current # of key pieces/ 100 ft of stream[‡]
Baker Creek	12/1/83	1.38	60.5	106.3	62	1.20	1.10
Bear Creek	2/1/84	14.75	40.0	6.6	41	0.17	0.22
Bridge Creek	6/1/82	1.25	38.6	74.9	39	0.85	0.81
Eubanks Creek	n/a	1.5	7.0	11.3	7	0.06	0.46
Harris Creek	2/1/83	1.75	16.0	22.2	16	0.55	n/a
Indian Creek	4/1/81	2.5	16.0	15.5	16	0.37	1.20
Jewett Creek	4/1/81	2.5	14.0	13.6	14	0.14	0.33
Mattole River (Headwaters)	n/a	6.48	22.0	8.2	23	0.09	0.38
Mattole Canyon	n/a	0	1.0	n/a	1	n/a	n/a
Upper Mill Creek	11/1/84	7.48	152.5	49.4	155	1.82	n/a
Nooning Creek	8/1/80	4.5	4.5	2.4	5	0.08	0.37
S.F. Bear Creek	10/1/83	9.5	75.0	19.1	76	0.19	0.90
S.Fk. Bridge Creek	6/1/88	1	9.0	21.8	9	0.25	n/a
Stanley Creek	5/1/84	0.63	93.0	357.9	95	4.06	0.70
Thompson Creek	11/1/84	3.75	18.0	11.6	18	0.15	1.33
Van Arken Creek	6/1/88	3.63	63.0	42.0	64	1.08	1.60

**Data compiled by Gary Flosi, CDFG, and John Wooster, Redwood Sciences Lab. Data accessed via KRIS Mattole: http://www.krisweb.com/krismattole/krisdb/webbuilder/bw_ct42.htm.*
[†] *Key piece calculations based on assumptions about piece volume and are meant only for comparison between amount removed and current amount.*
[‡]*Current wood data from 2005 and 2007 MRC surveys (MRC 2008).*

Not only has wood removal left many reaches in the Mattole bereft of instream wood, but also the logging of mature riparian forest has left a wood "recruitment gap" throughout the watershed. Young forests do not contribute any trees to the stream, or trees that are recruited are of insufficient size to have an impact on instream habitat. This gap is evident in the lack of "primary pools" and "key pieces" of large wood throughout the watershed, shown in Table 8. The vast majority of 81 stream reaches surveyed throughout the watershed rated "poor" in primary pools and wood abundance when compared to targets developed by the Central California Coast Coho Recovery planning team (NMFS 2010). The data in Table 8 show that conditions concerning pools and wood abundance are better in the Western and Southern Subbasins (the only subbasins with consistent coho presence), than in the rest of the watershed, but are still poor.

Table 8. Riparian canopy cover, % of primary pools, and large wood "key pieces"/100 ft of stream in 81 Mattole stream reaches, compared to target habitat values from *CCC Coho Salmon ESU Draft Recovery Plan* (NMFS 2010).

Rating, Criteria, and % of Surveyed Reaches in Each Category*				
Subbasin (& # of reaches)	**Poor (% of reaches)**	**Fair (% of reaches)**	**Good (% of reaches)**	**Very Good (% of reaches)**
% of Riparian Canopy Cover	**<75**	**75-85**	**85-95**	**>95**
All reaches (81 reaches)	32%	21%	**40%**	7%
Eastern Subbasin (23)	**35%**	13%	**35%**	17%
Northern Subbasin (14)	**64%**	21%	14%	0%
Southern Subbasin (21)	19%	24%	**57%**	0%
Western Subbasin (23)	22%	26%	**43%**	9%
% of reach by length composed of primary pools†	**<30%**	**30-40%**	**40-50%**	**>50%**
All reaches (81 reaches)	**85%**	9%	4%	2%
Eastern Subbasin (23)	**96%**	4%	0%	0%
Northern Subbasin (14)	**100%**	0%	0%	0%
Southern Subbasin (21)	**62%**	24%	10%	4%
Western Subbasin (23)	**87%**	3%	3%	3%
Large Wood Key Piece‡ Frequency/100 ft of stream	**<1.2**	**1.2-1.8**	**1.8-3.4**	**>3.4**
All reaches (81 reaches)	**75%**	12%	7%	0%
Eastern Subbasin (23)	**70%**	26%	4%	0%
Northern Subbasin (14)	**86%**	14%	0%	0%
Southern Subbasin (21)	**76%**	5%	19%	0%
Western Subbasin (23)	**74%**	22%	4%	0%

**Data from Mattole Restoration Council surveys in 2005 and 2007 (MRC 2008).*
†A "primary pool" has a depth of >2 ft in 1st & 2nd order streams and >3 ft in larger streams.
‡NMFS (2010) defines a "key piece" of large wood as >1.8 ft diameter and >32.8 ft in length. The large wood data in this table account for pieces >1 ft in diameter, and >20 ft in length, so this is an overestimate of key piece frequency according to the NMFS definition.

While neither metrics of "key pieces" nor "primary pools" are direct measures of winter rearing habitat quality, they are reasonable proxies. Mattole tributaries and the upper mainstem do not have extensive floodplains or stream-associated wetlands, which makes habitat created by instream wood an essential source of flow refuge. Wood and increased instream complexity also trap and slow down the export of nutrients, leading to increased productivity.

Comparing the percentage of reaches rated poor, fair, or good based on the percentage of the reach length composed of primary pools from mid-1990s data to more contemporary data shows relatively little change in pool frequency (Figure 23). Without substantial inputs of large instream wood throughout the watershed, these numbers will likely continue to remain static. Instream habitat restoration by the Mattole Salmon Group has greatly increased the incidence of wood in reaches where such projects have been implemented, up to five times the amount in un-treated reaches (Justice 2007). In some targeted reaches, however, the scale of the wood deficit throughout the watershed is formidable, and many past projects have focused primarily on summer-rearing habitat.

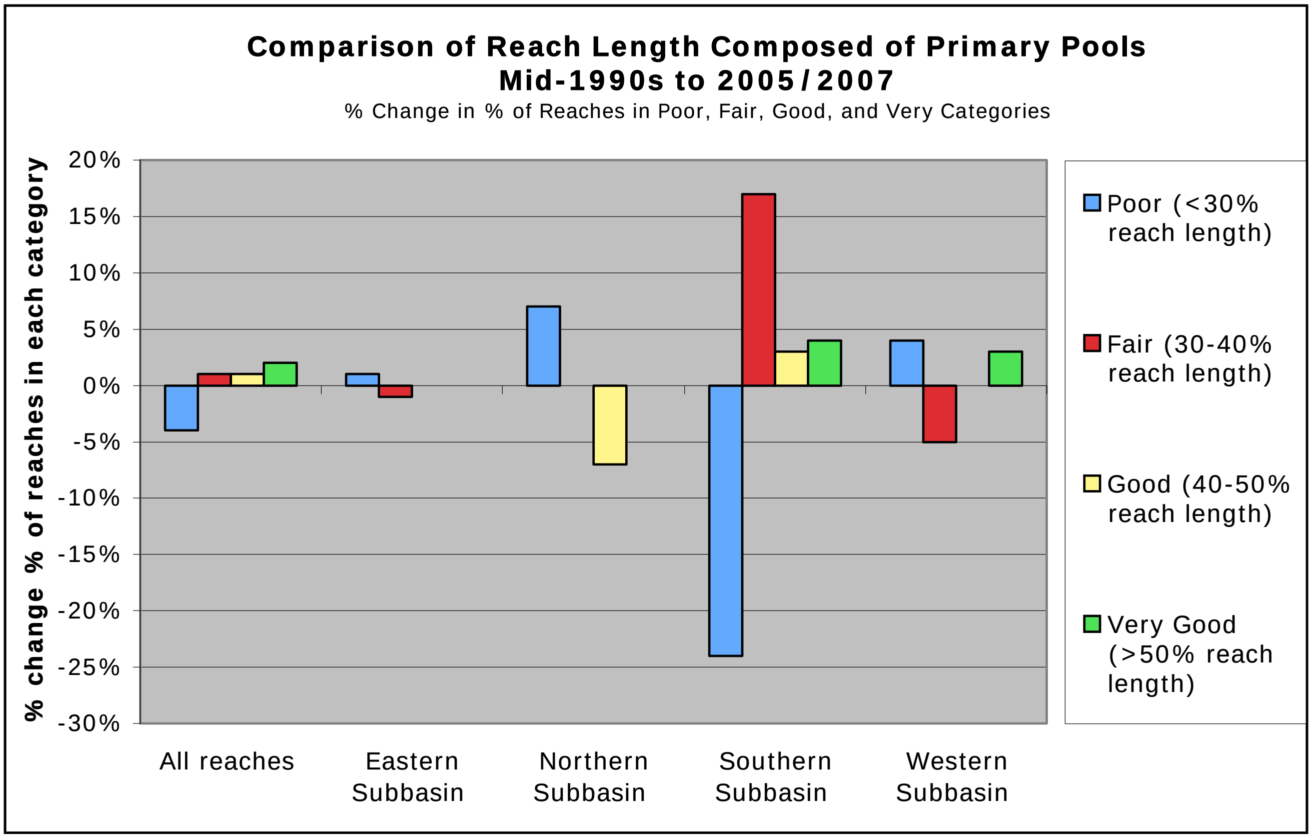


Figure 23. Percent change in ratings by subbasin from mid-1990s to 2005-2007of the percentage of reach length composed of primary pools..

Category definitions from the CCC Coho Salmon ESU Draft Recovery Plan *(NMFS 2010). Mid-1990s data from CDFG surveys (Downie et al 2003), 2005 and 2007 data from MRC surveys (MRC 2008).*

Woody habitat and primary pools are particularly lacking in areas lower in the system, and chronic turbidity may also pose an additional threat in such locales. The severity of this threat depends on the extent of current or possible juvenile use of the lower mainstem Mattole during the winter months. While no continuous turbidity sampling data has been collected in the Mattole, recent manual turbidity sampling during 2008-09 and 2009-10 has been conducted on 11 Mattole tributaries downstream of the town of Honeydew as part of a study of the effectiveness of sediment reduction work. These tributaries include streams that have a reputation as being the most turbid in the Mattole, based on visual observation. Despite such claims, the data suggest that turbidity does not or only slightly exceeds threshold levels indicative of “cumulative watershed effects on anadromous salmonid habitat capacity and stream ecosystem productivity,” as proposed by Klein et al. (2008). This holds true even in the most turbid drainages of the watershed. Table 9 shows the six streams with the most complete datasets. Observations by personnel conducting spawning ground surveys suggest that tributaries currently used by coho have a turbidity regime more similar to Lower Mill Creek (Table 9), as streams typically are clear enough to survey a day or two after storm events. In contrast, the mainstem Mattole just downstream of Honeydew all the way to the ocean runs noticeably brown much of the winter. While the turbidity duration or values have not been quantified for the lower mainstem, observations since

2008 suggest that this section of river stays noticeably turbid two or three times longer than the most turbid of the tributaries in Table 9.

Table 9. Turbidity data from six lower Mattole tributaries, water-year 2010, compared to thresholds proposed for North Coast watersheds by Klein et al. (2008) indicating "cumulative watershed effects on anadromous salmonid habitat capacity and stream ecosystem productivity."

Turbidity Threshold Value		**10 NTU**		**25 NTU**		**50 NTU**	
# of days exceeding value between Nov 15 - Jun 15 indicating "significant cumulative watershed effects"		***116*** *(55% of period)*		***42*** *(20% of period)*		***21*** *(10% of period)*	
		Total Days Exceeding NTU Threshold*					
Stream	**Drainage Area (miles^2)**	Directly Measured	High Estimate	Directly Measured	High Estimate	Directly Measured	High Estimate
Lower Mill Creek	2.10	15	34	5	15	1	7
East Branch East Mill Creek	0.86	15	34	9	19	6	12
Lower Bear Creek	0.59	46	65	16	26	8	14
West Branch East Mill Creek	0.89	35	54	17	27	10	16
Cook Gulch	0.61	50	69	34	**44**	20	**26**
Upper North Fork Mattole	26.09	60	79	36	**46**	17	**23**

Note: numbers in bold represent are those that exceed the threshold.

"Directly Measured" columns show number of days samples from each stream exceeded each threshold. "High Estimate" columns are a liberal estimate of the possible # of days that exceed threshold of each value in order to account for sampling effort, based on # of sampled days plus one day for each storm event that generated value that exceeded threshold at Lower Bear Creek.

Many of the middle and lower river tributary streams with the most extensive low-gradient reaches are larger tributaries (see Figures 3 and 4, pgs. 11-12) that suffered disproportionate impacts from the coincidence of land-use practices and large floods during the last 70 years. Examination of aerial photos taken prior to these major ecosystem disturbances shows narrow stream channels often hidden beneath a canopy of mature conifers. Unregulated timber harvest in the 1940s-60s removed the primary source of large wood and often involved the removal of riparian trees, using terraces and floodplains as haul roads. These activities increased the chance for transport and re-working of floodplain sediments in high flows. The flat, featureless channels and floodplains that resulted have been slow to recover naturally, as the predominantly coarse floodplain material is ill suited for the establishment of woody plants. While it remains unclear if temperatures in the low-gradient reaches of tributaries such as Mattole Canyon, Blue Slide, Squaw and Honeydew Creeks were ever sufficiently cool enough to be suitable coho summer rearing habitat, it is likely these reaches historically provided high-quality winter rearing habitat for juveniles either spawned further upstream in the same tributary, or non-natal refugees from another stream.

3. Data Gaps

While tributary snorkel surveys in the fall and DSMT operations in the Mattole yield relative abundance estimates for juveniles and smolts, these estimates are not a suitable means for calculating juvenile to smolt survival rates. As mentioned previously, the small number of coho outmigrants captured in the lower mainstem DSMT does not result in statistically significant population estimates.

The CDFG-based 10-pool protocol snorkel surveys in the fall are focused on determining juvenile distribution and oversummer survival rather than generating a YOY population estimate, although they do provide some information on relative abundance from year to year. It should be noted, however, that the juvenile dive surveys cover only specific stream reaches and can yield basinwide abundance estimates only with a high degree of uncertainty. In addition, survey coverage from year to year has been variable, making comparisons difficult in some cases (e.g. Yew and Thompson were not surveyed in 2005 or 2006 due to funding constraints).

Furthermore, almost nothing is known about the movements of fry or pre-smolt coho during the late fall, winter, and early spring throughout the Mattole, or how dependent these movements are on exposure to turbid conditions, high flows, predation, or competition for space. Additionally, no data exist from the Mattole on the extent of predation on coho juveniles.

4. Research from Other Watersheds

The important role of instream wood in creating and maintaining aquatic habitat in the Pacific Northwest has been well documented. Abundant instream wood contributes to overall channel heterogeneity and habitat diversity by creating local-scale variation in channel hydraulics, and increases the frequency and volume of pools in forest streams (Beechie and Sibley 1997, Fausch and Northcote 1992, Hogan 1987, Keller and Swanson 1979, Rosenfeld and Huato 2003, Woodsmith and Swanson 1997). Instream obstructions created by wood can significantly change channel morphology both upstream and downstream by creating sediment storage sites, retaining gravels suitable for spawning (Bilby and Bisson 1998, Hogan 1987, Keller and Swanson 1979), and by raising the stream base level, forcing meandering and pool development (Montgomery and Buffington 1998, Woodsmith and Buffington 1996). The removal or loss of in-channel wood can lead to channel incision, thus isolating channels from floodplains (Woodsmith and Swanson 1997). Log jams, and the complexity created by wood not only provide substrate and cover for a number of organisms (Wondzell and Bisson 2003), but retain organic matter and nutrients in the stream system as well, leading to overall greater productivity (Bilby and Bisson 1998, Brookshire and Dwire 2003, Richardson et al 2005). Larger individual wood pieces and accumulations with greater total volume have a disproportionately significant impact on pool volume and channel morphology (Bilby and Ward 1989, Rosnenfeld and Huato 2003).

Correlations between mild spring flows and high rates of egg-to-juvenile survival for coho have been reported in Lagunitas and Redwood (Marin County) Creeks (Ettlinger et al. 2009a, Carlisle et al. 2008). A high degree of channel confinement in Redwood Creek is hypothesized to contribute to consistently lower egg-to-juvenile survival in that stream than in neighboring watersheds. The outmigrant trap in Redwood Creek also captures a relatively high percentage of YOY, likely prematurely forced downstream due to a lack of flow refuge (Carlisle et al. 2008). In other watersheds just to the north of the Mattole, recent studies have found a large number of juvenile coho moving (or being displaced by high flows) downstream in the fall and winter as a result of high flows (Brakensiek 2002, McCoy 2008, Wallace 2010). Locations lower in the stream network offer warmer water temperatures and higher biological productivity, and in some cases, greater opportunities for low-velocity refuge from high flows.

Significant fry displacement or direct mortality over the winter has been documented as a significant limiting factor in other watersheds, especially in years with high flows in late spring (Carlisle et al.

2008, Ettlinger et al. 2009a). In some Marin County streams, and Russian River and Smith River tributaries, markedly low overwinter survival seems to be correlated with high flow events (Carlisle et al. 2008, Obedzinski et al. 2008, Stillwater Sciences 2006).

Mortality of coho juveniles due to a lack of suitable overwinter rearing habitat, which includes refuge from high flows, can cause mortality and has been cited as the factor most limiting smolt abundance in a number of coastal watersheds in Oregon and California (Gonzales 2006, Nickelson 1998, Solazzi et al. 2000, Stillwater Sciences 2006, Stillwater Sciences 2008). Regional survival rates vary widely year to year, with studies reporting 4-61% survival in Marin County streams (Carlisle et al. 2008), 5-56% in Russian River tributaries (Obedzinski et al. 2008), and 2-63% in coastal Oregon (Ebersole et al. 2009a).

High site fidelity and rearing density through winter high flows has been found in habitats which offer the greatest velocity refuge from stormflows. Juveniles will move from main channel pools, many of which offer little velocity refuge during high flows, into off-channel areas such as alcoves, backwater pools, or beaver ponds (Bell et al 2001, Nickelson et al. 1992b). Loss of access to floodplains caused by cannel incision likely has negative consequences for coho growth as well, since terrestrial food inputs from seasonally flooded habitats can make up a significant portion of the winter diet of juveniles (Bell et al 2001, Pert 1993). Off-channel habitat can also provide refuge from higher turbidities in main channels. This allows juveniles to feed and grow without experiencing the negative effects of turbidity on these processes, as high turbidities have been shown to have negative effects on the ability of juveniles to feed and grow (Klein et al. 2008).

Increasingly, researchers are observing fall redistribution of juvenile coho to be a significant phenomenon (Brakensiek 2002, Lestelle 2007, Sutton and Soto 2010), challenging the notion that coho always rear in their natal streams. In one of the most extreme cases reported, a YOY coho PIT-tagged in a mid-Klamath River tributary traveled 115 miles downstream from August to January, and was captured ascending a tributary a few miles upstream from the estuary (Hillemeier et al. 2009). This redistribution may be due in part to fish seeking out additional or more favorable rearing habitats, being swept downstream with the first major stormflows of the fall, or be an expression of alternate life history strategies.

In the mainstem Mattole, access to off-channel habitats where turbidities are lower and low-gradient lower river tributaries with suitable flow refuge would likely be important factors in influencing the survival of such "refugees' in the lower river. Reducing sediment loads in the lower river and increasing wood inputs will be necessary to recreate suitable winter rearing habitat for juveniles displaced or redistributed from their natal streams.

Other factors besides high flows have been found to influence juvenile-to-smolt survival in other watersheds within the Pacific Northwest. In streams in California, Oregon, and Washington, greater juvenile fork length in the fall has been positively correlated with higher overwinter survival rates (Brakensiek and Hankin 2006, Ebersole et al. 2006, Obedzinski et al. 2008, Quinn and Peterson 1996). Greater size may enable juvenile fish to physically withstand higher flows without being swept away, or increase their ability to compete for limited off-channel refugia during stormflows.

Analysis of population estimates from Lagunitas Creek has shown a general trend of increasing winter mortality correlated to greater abundance of juvenile coho in the fall (Stillwater Sciences 2008, Stillwater Sciences 2009). Limited carrying capacity of winter habitat seems to result in a relatively stable maximum number of surviving smolts, despite beginning the fall with widely differing numbers of juveniles. In years of very low fall abundance of juveniles, overwinter survival is very high. In these years, early life stage mortality is a more important factor limiting smolt abundance, rather than carrying capacity of winter habitat. The contrast is true in years with high fall abundance, when limited carrying capacity leads to high winter mortality.

Current limited wintertime carrying capacity related to lack of flow refuge and slackwater habitat seems to be a common thread among coastal watersheds in the Pacific Northwest. In the CCC ESU, habitat parameters used as indicators of winter rearing and smolt habitat have the highest percentage of “poor” ratings across all populations in the ESU; these parameters include shelter, primary pools, wood loading, and habitat complexity (NMFS 2010). Relatedly, in the Stillaguamish River basin in Washington, Beechie et al. (1994) and Pollock et al. (2004) analyzed the lost smolt production potential (SPP) due to losses in slackwater habitat caused by land use in the watershed since Euro-American settlement. They found an 86% reduction in overall winter habitat SPP, most of which was due to the loss of beaver ponds, and the beaver to create them.

Increases in instream wood loading, either natural or placed, have been linked to increased coho over-wintering survival (Cederholm et al. 1997, Nickelson et al. 1992a, Johnson et al. 2005), growth (Cederholm et al 1997, Fausch and Northcote 1992), and rearing density (Cederholm et al 1997, Fausch and Northcote 1992, Nickelson et al 1992b, Roni and Quinn 2001). The most suitable habitats are larger, more complex pools, such as those created by beaver dams or large wood accumulations that offer the most cover and velocity refuge, and thus result in better growth and survival (Fausch and Northcote 1992, McMahon and Hartman 1989, Nickelson et al 1992b, Quinn and Peterson 1996, Roni and Quinn 2001).

5. Summary

Factors which are likely limiting survival and growth of coho fry and juveniles include the duration of high flows, the availability of flow refuge, and chronic turbidity in the lower mainstem Mattole. However, in reaches with documented coho spawning activity, we do not believe turbidity duration is a significant issue.

While we have no direct evidence of significant juvenile mortality due to high flows, we do know that flow refuge is severely lacking throughout the watershed. Research from other watersheds suggests that lack of sufficient wintertime rearing habitat is a key limiting factor to coho salmon recovery in those systems. The loss of functional instream wood in the Mattole has greatly simplified channels, decreased or eliminated the presence of cover and velocity refuge, and decreased nutrient retention and food availability. Wood placement in coho streams has been a focus of Mattole restoration activity, but until recently, has focused on improving summertime rearing conditions. High flow refuge in the form of slack and slow water habitat is in gravely short supply in many reaches, and thus is determined to be a major factor limiting survival of coho salmon in the Mattole River Watershed. Increased wood loading and creation of slack water habitats will increase habitat complexity and will also have positive benefits for stream productivity and fish growth. Improving the quality of winter-time habitat in non-natal stream reaches – including the lower river and the largest tributaries – also appears to be an important factor in improving over-winter growth and survival of multiple coho life-histories.

D. Juvenile Summer Rearing

1. Habitat Requirements

Adequate water quality, cover from predation, and food availability are all necessary requirements for the successful oversummer rearing of juvenile coho. The suitable temperature range for survival of juvenile coho is 1.7-22.8°C (35-73°F), however, the preferred range is much narrower at 11.7-13.9°C (53-57°F). Dissolved oxygen levels also heavily influence successful rearing. According to the California State Water Resources Control Board (Carter 2008), salmonids can survive in waters with DO levels as low as 3 mg/L but slight production impairment begins to occur at levels as low as 6 mg/L. Spence et al. (1996) recognized 3.3 mg/L as a lethal DO level for salmonids, but also noted that reduced growth occurred at 5.0 mg/L.

Ideal summer rearing sites provide cover in the form of overhanging banks and wood accumulations, while allowing access to drift for feeding. Habitats with these conditions are typically found in streams with large wood structures, spring fed ponds, and protected side channels. Vegetation along the streambanks further provides important nutrients and food for rearing coho (CDFG 2002). Survival can be strongly density dependent, especially as available space shrinks with declining summer flows (Lestelle 2007).

2. Habitat Conditions

High water temperatures, severe low summer flows, and limited habitat complexity all appear to be important factors in reducing the quality and quantity of oversummering habitat for coho in the Mattole.

Juvenile coho are the least tolerant of high temperatures of any Mattole salmonid (Coates et al. 2002). A 2001 study in the Mattole River Watershed found juvenile coho distribution strongly correlated with Maximum Weekly Average Temperatures (MWATs) of less than 16.7°C (62.06°F) and Maximum Weekly Maximum Temperatures (MWMTs) of less than 18.0°C (Welsh et al. 2001). Based solely on this threshold, suitable thermal habitat for oversummering juvenile coho exists only in smaller tributaries (many of them in the middle and lower watershed at relatively high gradient) and the uppermost 5-10 miles of the Mattole River mainstem (Figures 24 and 25). Although some lower and middle Mattole tributaries are cool enough to support coho and have historically provided oversummering habitat (Table 10, pg. 59), coho presence in such reaches has become increasingly rare in the past decade (Table 1, pgs. 13-14). High summer water temperatures are a major factor limiting the distribution and summertime survival of coho salmon in the Mattole River watershed.

As noted in the previous section (III.C.2), the Mattole headwaters and tributaries (located in the Southern Subbasin) contain the best-quality instream habitat in the watershed, with the lowest levels of fine sediment, the greatest number of high-quality pools and large wood (Table 8, pg. 48), and water temperatures that are suitable for coho oversummering (Figures 24 and 25). Recently, a new threat to quality coho habitat in the headwaters has emerged. In 9 out of the 12 summers since 1999, portions of the mainstem Mattole upstream from Bridge Creek (RM 52.1) have broken into disconnected pools or become completely dry, as have 11 of the 15 headwaters fish-bearing tributaries (Figures 26 and 27).

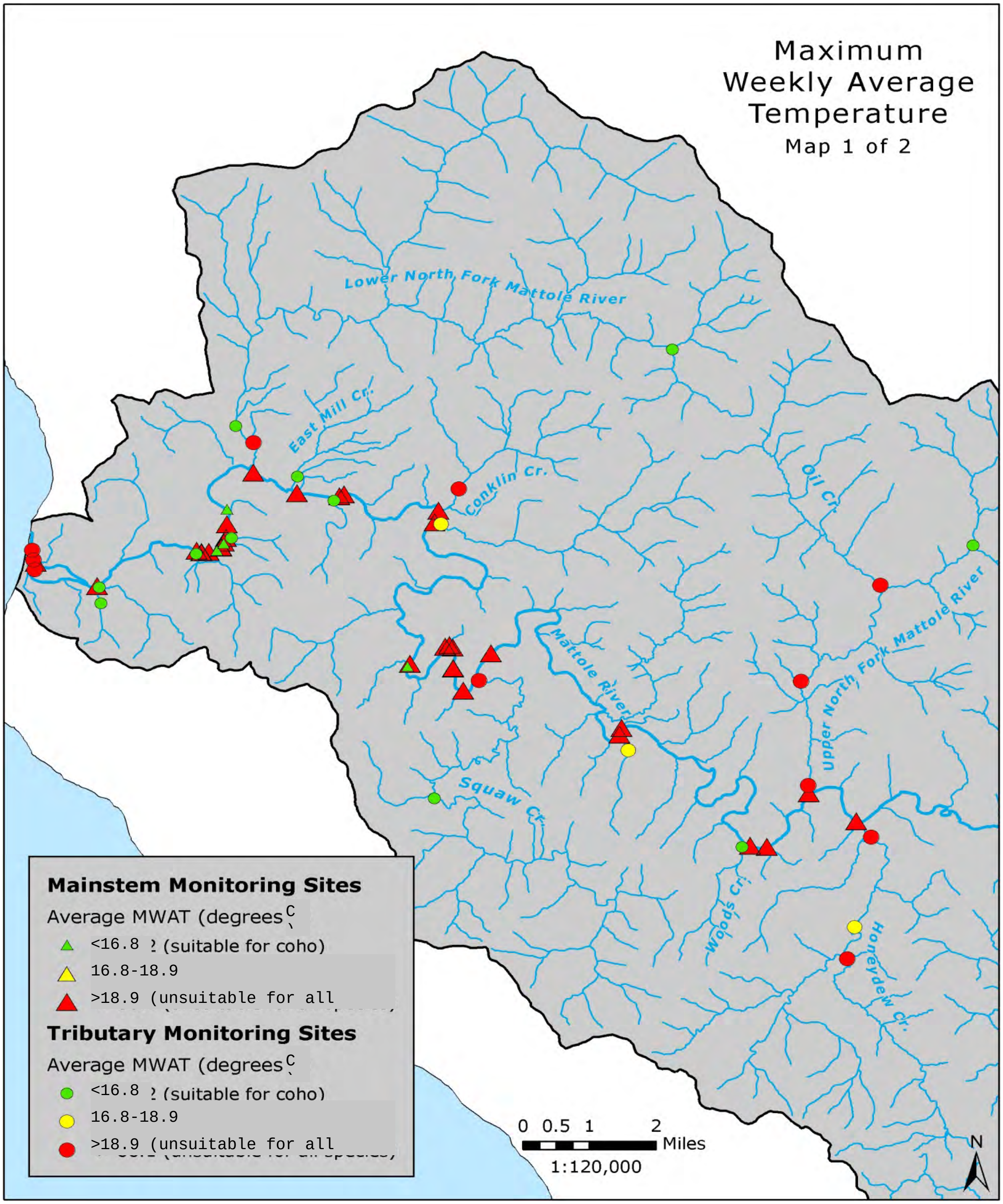


Figure 24. Average Maximum Weekly Average Temperatures (MWATs) from years surveyed in the Mattole River Watershed, from the estuary to Honeydew Creek (RM 26.5), MSG temperature monitoring data, 2000-08.

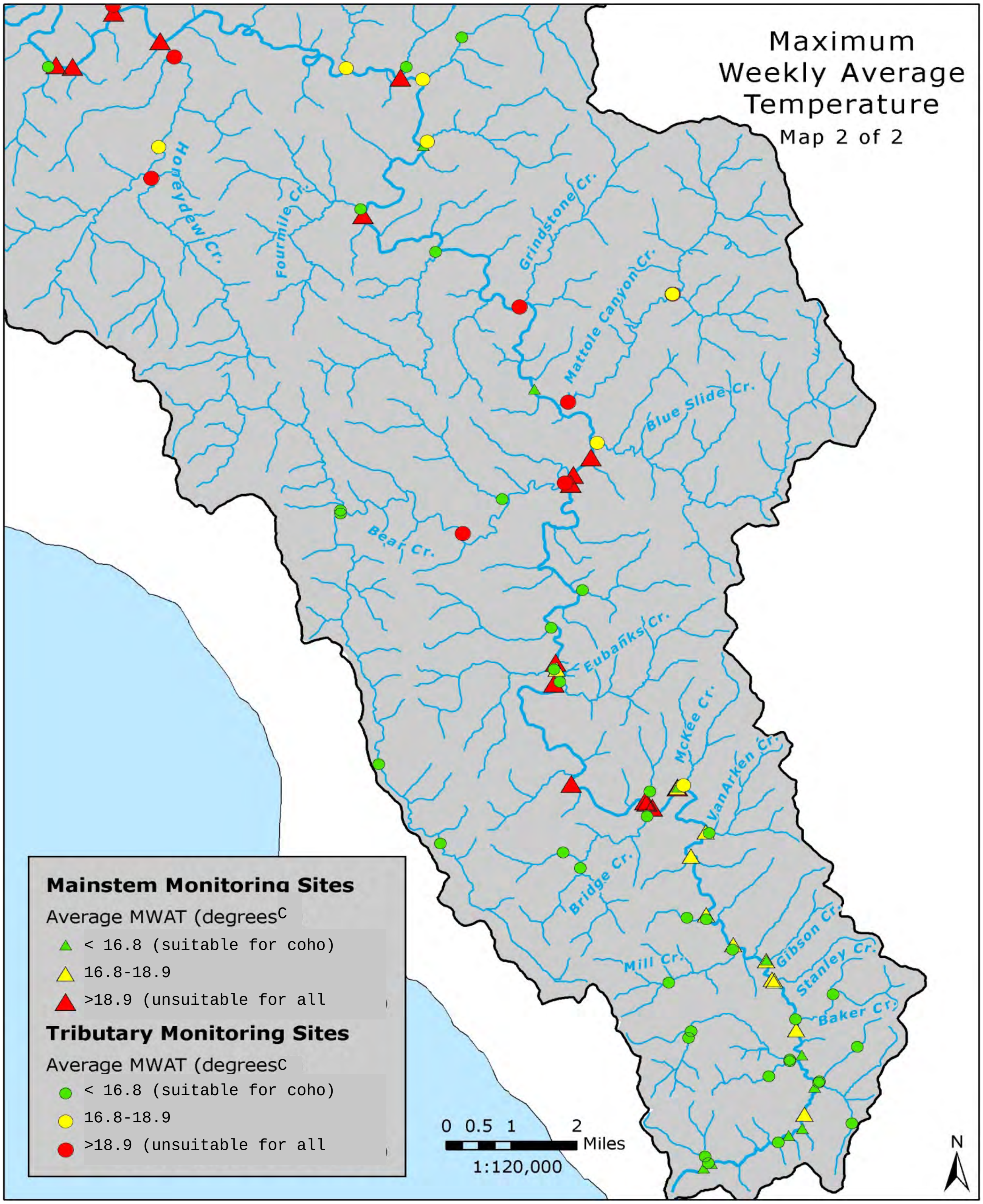


Figure 25. Average Maximum Weekly Average Temperatures (MWATs) from years surveyed in the Mattole River Watershed, from Honeydew Creek (RM 26.5) to the headwaters, MSG temperature monitoring data, 2000-08.

Dry or Intermittent Stream Reaches
Mattole Headwaters 2004-2009

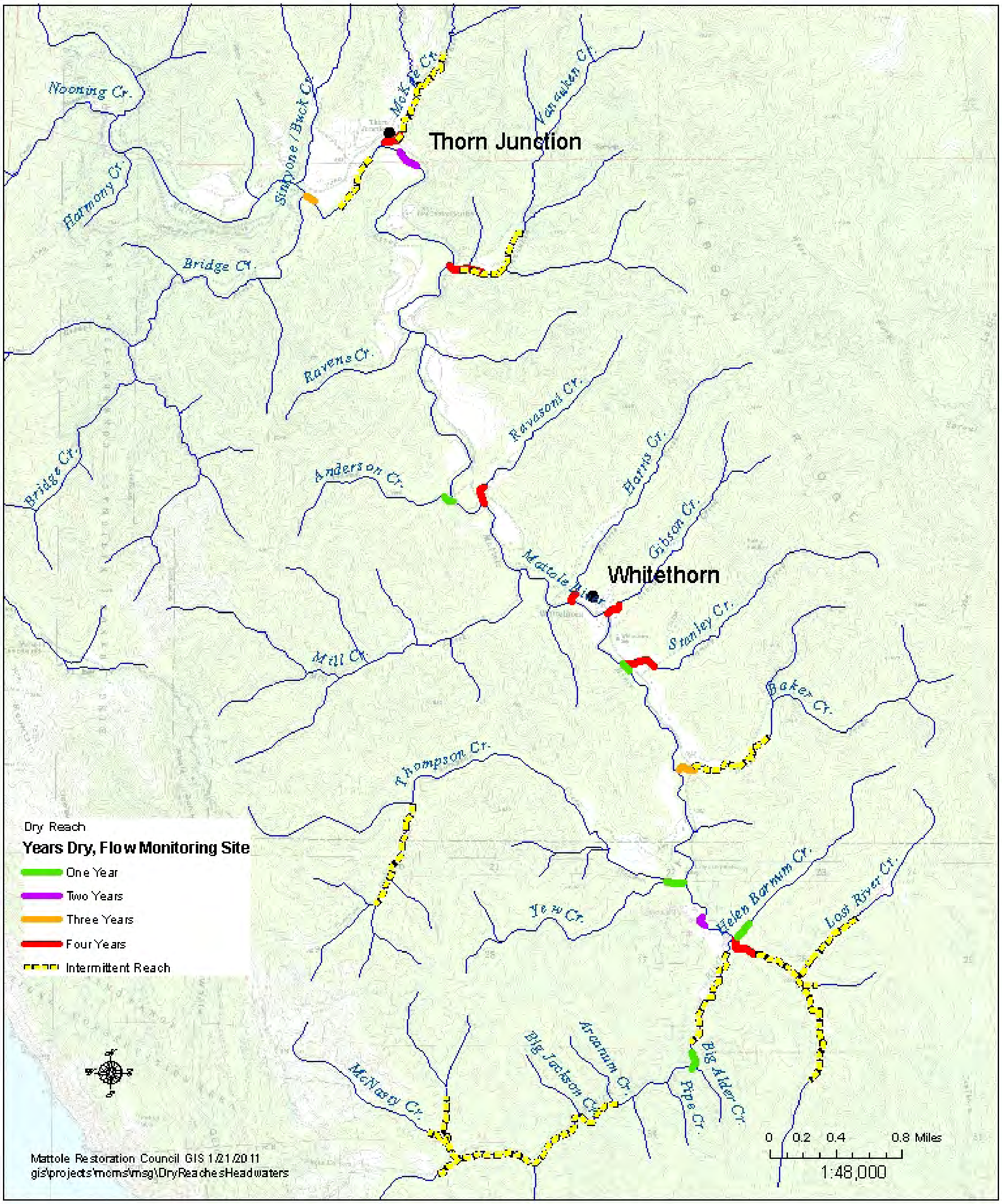


Figure 26. Draft map of dry and intermittent stream reaches in the Mattole headwaters at monitored locations, 2004-09.
Note: this map is an underestimate of the total extent of stream drying, as dry reaches have not been mapped extensively, especially in tributaries, and additional sections of the mainstem Mattole become intermittent between Whitethorn and Bridge Creek.

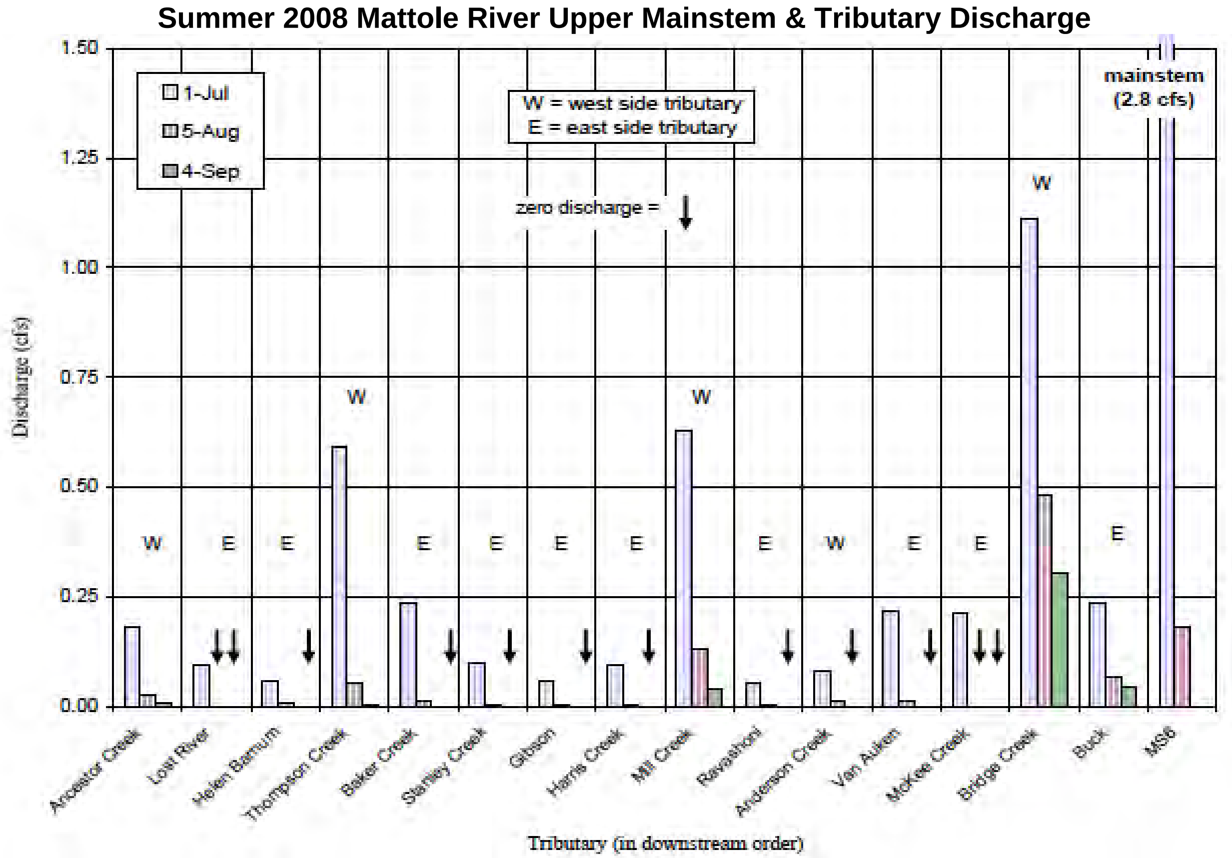


Figure 27. Upper Mattole tributary and mainstem discharges, summer 2008.
Graph from Klein (2009).

Since 2004, Sanctuary Forest has conducted extensive streamflow and groundwater monitoring to develop a better understanding of the conditions contributing to the low-flow crisis. Analyses points to climate change and a longer dry season as the primary causes for the unprecedented low flows in recent years (Klein 2007, McKee 2004a). Human water use, high evapotranspiration rates from dense young forests, and hydrologic changes relating to past road-building and timber harvest further contribute to the problem (Klein 2007, McKee 2004a).

The MSG conducted repeated snorkel surveys to enumerate juvenile salmonids in the Mattole headwaters through the low flow season in 2007 and 2008. Pool dimensions, water quality parameters, and streamflow were also measured. In 2007, snorkel survey counts were conducted in 38 randomly selected pools in a one mile reach between Big Alder (RM 59.4) Creek and Thompson Creek (RM 58.4) of the upper mainstem. In 2008, these surveys were conducted in four reaches containing ten pools each: adjacent to Sanctuary Forest monitoring sites MS1 (Mattole mainstem, RM59.8) and MS2 (Mattole mainstem, RM 58.9), and in Upper Mill Creek (RM 56.2) and McKee Creek (RM 52.8), beginning at the creek mouth and proceeding upstream. While obtaining accurate population and survival estimates from snorkel surveys of pools is confounded by changes observer efficiency related to streamflow changes, fish use of non-pool habitat, and the inability to account for emigration and immigration (Brakensiek 2002, Ettlinger et al. 2009, Obedzinski et al. 2008), the observed relationships among fish abundance, temperature, DO, and declining flows lend insight into habitat conditions and juvenile coho mortality over the summer.

Table 10. Summary of changes in juvenile coho and steelhead counts and dissolved oxygen concentrations, Mattole River headwaters, 2007 and 2008.

2007 Apparent % Survival (%), based on peak count recorded on 9/10	**Coho**	**Steelhead <100mm**	**Steelhead >100mm**
Entire reach, 9/10/07 to 9/24/07	42.8	60.0	79.6
Entire reach, 9/10/07-10/10/07	37.4	48.3	95.5
2008 Apparent % Survival, based on counts recorded on 8/14	**Coho**	**Steelhead<100mm**	**Steelhead>100mm**
McKee, 08/14/08 – 09/15/08	0.00	0.00	0.00
Mill, 08/14/08 – 09/15/08	60.00	52.00	0.00
MS1, 08/14/08 – 09/15/08	19.00	32.00	7.00
MS2, 08/14/08 – 09/15/08	25.00	31.00	0.00
2007 Average DO (mg/L), based on 2 measurements/pool	**9/10/07**	**9/24/07**	**10/10/07**
Entire Reach	6.6	7.55	9.16
2008 Average DO (mg/L), based on 2 measurements/pool	**8/14/08**	**9/15/08**	
McKee	4.24	1.38	--
Mill	8.26	9.42	--
MS1	5.29	4.19	--
MS2	5.18	3.60	--

In both 2007 and 2008 peak counts of coho and steelhead were roughly concurrent with the onset of the period of lowest flows of the season, and subsequent surveys documented large declines in the number of coho and steelhead (Table 10 and Figure 28). The lesser numbers of fish observed earlier in the season (Figure 28), was most likely due to fish utilizing riffle and glide habitat that was not surveyed, and then being confined to pools as flows declined (Figure 29). In 2007 movement of fish in or out of the survey reach could have skewed survival estimates (although some pools in the reach were disconnected from September to October). In 2008, the McKee Creek, MS1, and MS2 reaches dried to isolated pools by August 14 (Figure 29), and in the McKee reach, eight of the pools dried completely, so the observed decline in survival in the subsequent four weeks cannot be attributed to fish leaving the survey reaches, but represents true mortality.

In 2008 flows were lower earlier and remained low (or nonexistent) much longer than in 2007 (Figures 29 and 30). Corresponding DO concentrations at MS1 and MS2 sites were much less favorable in 2008 than in 2007, and for a much longer duration (Table 10 and Figure 29). Dissimilarly to the other three sites in 2008, Upper Mill Creek continued to flow through September, resulting in DO levels that never approached 6 mg/L, which is the production impairment threshold for DO determined by Carter (2008). With even a maintained small amount of flow in Upper Mill Creek, DO levels improved from mid-

August to mid-September as stream temperatures decreased. Conversely, in the reaches with no flow, DO levels continued to decline throughout the survey period, and likely did not begin to increase until the first rainfall in October.

During both 2007 and 2008, temperatures remained suitable throughout the summer in the survey reaches, although nearby downstream temperatures in the mainstem (RM 53.8-52.2) exceeded the MWAT threshold beginning in the first week of July (Figure 31). Water temperatures generally peak by July or early August, and moderate somewhat by late August and September, when the lowest streamflows occur (Baier 2008).

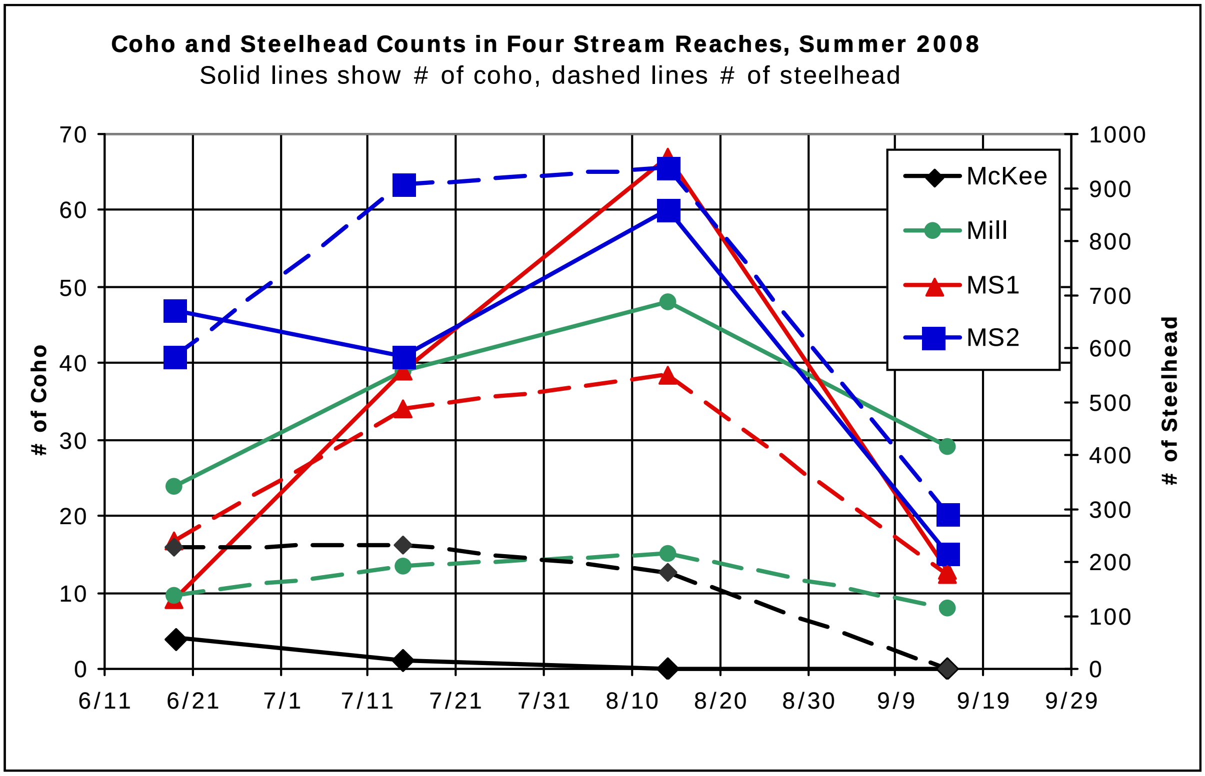


Figure 28. Coho and steelhead observed via repeated dive surveys, Mattole River headwaters, summer 2008.

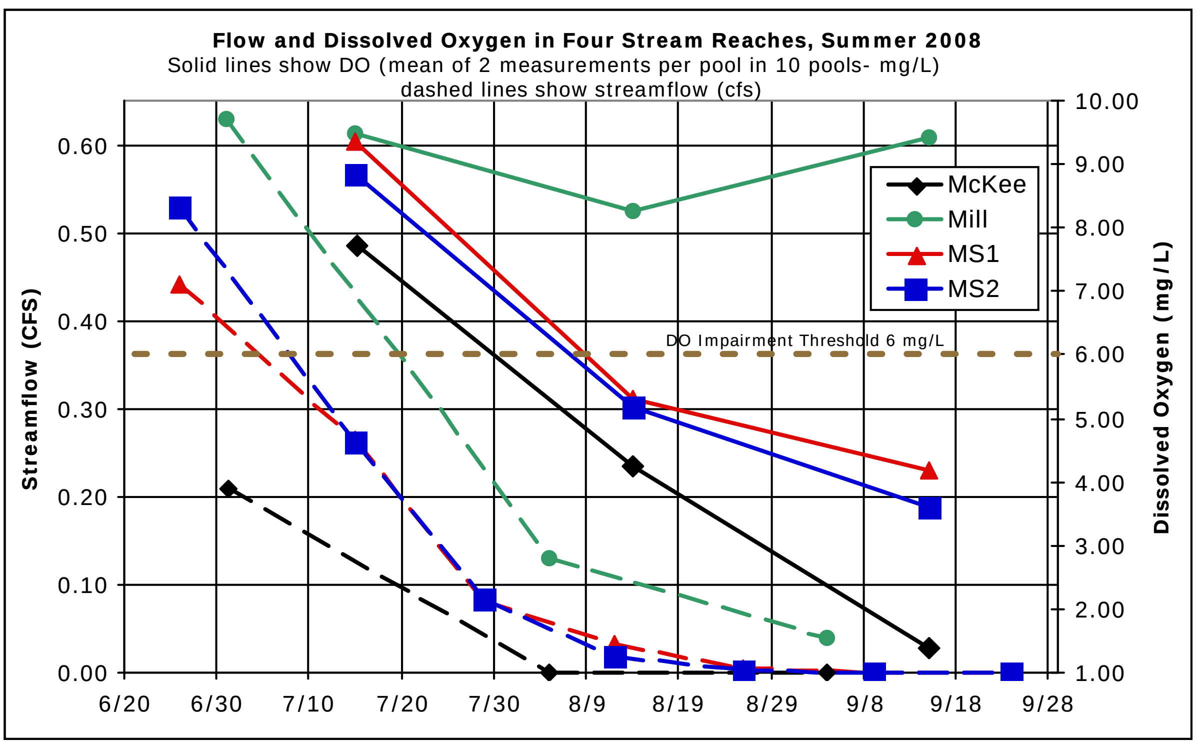


Figure 29. Streamflow, and mean dissolved oxygen (DO) concentrations in dive survey reaches, Mattole River headwaters, summer 2008.

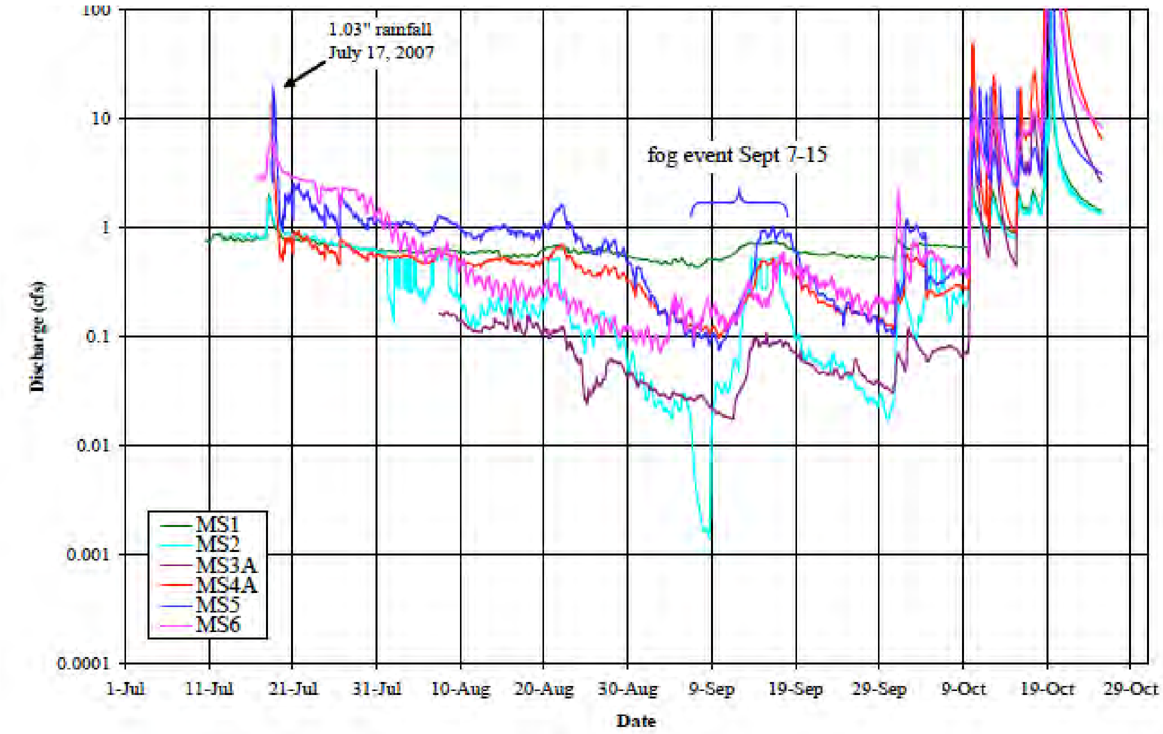


Figure 30. Continuous discharge at Upper Mattole River mainstem sites, summer 2007.
Graph from Klein 2009.

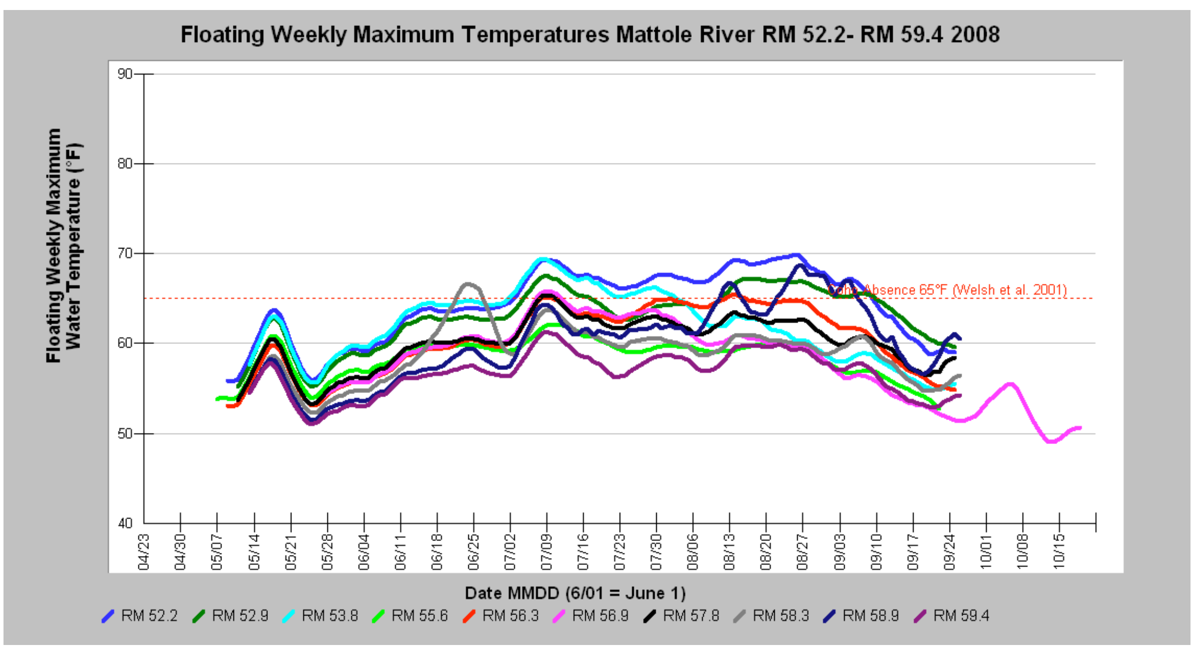


Figure 31. Floating weekly MWMT at 10 sites in the Mattole River headwaters, 2008, from site MS 6 (RM 52.2) upstream to Ancestor Creek confluence (RM 59.4).
Graph from Baier 2008.
Note: after mid-August the temperature probe at MS2 (RM 58.9) was periodically exposed to air due to low flows.

The results from 2007 and 2008 lend to the notion that even in "moderate" low flow years, much of the main summer rearing habitat utilized by Mattole coho is characterized by sub-optimal conditions, which lead to low survival in late summer. In years with very low flows, such as 2008, survival is very poor, and some reaches become completely dry, resulting in complete mortality. In this same year, the striking difference between apparent survival of coho juveniles (and steelhead) in Upper Mill Creek and the other three reaches surveyed suggests that even small increases in late summer flow – decreasing both severity and duration of low flow-related stresses – results in better rearing conditions and lower mortality rates.

The occurrence of unsuitable water temperatures in the Mattole mainstem in mid-summer likely limits the ability of juvenile coho to redistribute downstream in response to declining flows and shrinking habitat in the headwaters. Later in the summer, when more moderate water temperatures downstream might otherwise allow redistribution, portions of the mainstem are frequently dry. The mouths and lower reaches of many tributary streams are also dry in late summer, further limiting habitat availability (Figure 26).

As with winter rearing habitat, a lack of habitat complexity in the form of deep pools and cover provided by instream wood is negatively impacting summer rearing success. Table 11 shows ratings for Mattole streams that demonstrate the degree to which summer and winter rearing habitat have been compromised in much of the watershed. Pool and habitat volume, or lack thereof, are directly related to potential food sources, which can significantly affect growth and survival of juveniles, as well as the potential for predation. Due to severely limited suitable rearing habitat, juvenile coho – which are territorial by nature – may experience more acute stress and competition, which also can negatively affect growth and survival.

Despite the issues outlined previously in this section, coho summer rearing habitat in the headwaters remains more suitable than any other portion of the watershed. The headwaters is the area that has the greatest extent of low-gradient stream reaches with unconfined valleys, the most suitable water temperatures, and over the last decade, is where coho juveniles have been observed most consistently and in the largest numbers (Figures 32 and 33).

While summer low flows, high water temperatures, and a lack of habitat complexity all appear to be contributing to poor over-summering rearing conditions and high mortality for juvenile coho in the Mattole, low summer streamflow seems to be the primary driver responsible for many of the worst conditions. Summer streamflows, however, may also be the factor which management actions can most effectively address. With adequate summer flows, most stream reaches shown in Figure 26 will provide suitable summer rearing habitat for coho. The development of an older and more complex riparian canopy, in addition to instream wood loading, will also help reduce the cumulative stresses that produce the current suboptimal and hospitable conditions.

Table 11. Mattole tributaries and stream reaches and their summed IP, IP ranking, average MWAT (2000-10), and habitat ratings.*

Note: sediment, flow, and wood/complexity are rated based on current habitat conditions; ratings are from 1-5 with 1 rated as not limiting and 5 as very limiting.

Approx. River Mile (RM)	Tributary	IP Kilometers	Rank based on IP KM (smaller # has higher IP)	Average MWAT*, ^{o}C (2000-10)	Sediment Limited	Flow Limited	Wood/ Complexity Limited
1.0	Lower Bear	0.10	69	14.36	3	5	4
1.3	Stansberry	0.59	56	15.16	2	2	4
1.8	Jim Goff	1.70	34	--	4	2	3
2.8	Lower Mill	0.00	--	14.76	2	1	3
4.7	Lower North Fork Mattole	11.60	5	20.76	5	2	4
5.4	East Mill	4.87	12	16.34	3	2	5
6.1	Clear	0.07	71	15.13	2	1	3
7.8	Conklin	2.25	27	19.15	5	3	4
8.0	McGinnis	3.59	17	18.44	4	2	4
11.7	Indian	0.58	57	--	2	1	2
14.9	Squaw	11.81	4	20.04	3	2	3
19.2	Pritchett	2.50	23	--	4	2	3
19.2	Granny	0.87	46	--	5	3	4
19.9	Saunders	0.33	61	17.26	3	4	4
24.1	Woods	0.95	45	16.20	2	2	3
25.5	Upper North Fork Mattole	5.82	9	21.41	4	2	4
26.5	Honeydew Excluding Lower E. Fork and Bear Trap	5.47	10	19.30	3	1	5
26.5	Honeydew (Lower East Fork)	2.34	25	18.21	4	1	4
30.4	Dry	1.99	29	18.69	4	3	4
31.3	Middle	0.82	47	16.42	2	3	4
31.7	Westlund	1.12	42	17.35	2	2	3
32.8	Gilham	0.37	60	16.92	2	1	3
34.6	Fourmile	2.64	22	17.51	4	2	3
36.6	Sholes	1.80	31	17.14	3	2	3
39	Grindstone	0.00		18.89	3	1	3
41.1	Mattole Canyon	6.83	8	19.09	4	4	4
42.0	Blue Slide	9.23	6	18.86	4	5	4
42.8	Bear (excluding N&S forks)	8.71	7	21.38	2	2	4
42.8	N. Fork Bear	1.73	33	16.59	2	1	3
42.8	S. Fork Bear	12.28	3	15.94	2	3	3
44.0	Wolf/ Box Canyon	0.32	62		3	2	3

Approx. River Mile (RM)	Tributary	IP Kilometers	Rank based on IP KM (smaller # has higher IP)	Average MWAT*, ^{o}C (2000-10)	Sediment Limited	Flow Limited	Wood/ Complexity Limited
45.9	Deer Lick	1.53	36	16.60	3	3	3
46.8	Little Finley	0.98	44	--	3	1	3
47.4	Big Finley	1.81	30	15.39	2	1	4
47.7	Eubanks	4.12	16	15.63	3	5	4
50.2	Nooning	0.75	49	--	2	1	3
52.1	Bridge	4.71	13	16.35	2	2	4
52.8	McKee	2.44	24	16.54	3	5	4
54.0	Van Arken	3.41	18	15.72	3	5	4
55.6	Anderson	0.64	52	14.77	3	5	4
55.8	Ravasoni (East Anderson)	1.46	38	--	3	5	3
56.2	Upper Mill	3.28	20	15.25	1	4	4
56.5	Harris	2.08	28	--	3	5	4
56.5	Mainstem above Whitethorn	13.38	2	14.93	2	5	5
56.8	Gibson	1.42	39	--	3	5	4
57.1	Stanley	1.80	32	--	2	5	4
57.6	Baker	3.21	21	15.22	3	5	4
58.4	Thompson	5.04	11	16.20	1	4	3
58.4	N. Fork Thompson (Danny's)	0.66	51	14.36	1	3	3
58.4	Yew (trib. to Thompson)	1.33	40	15.28	2	3	3
58.7	Helen Barnum	1.20	41	14.02	3	5	4
58.8	Lost River	3.07	15	15.04	3	5	4
60.8	Ancestor	1.02	43	13.53	3	5	2
60.8	McNasty (trib. to Ancestor)	0.73	50	13.23	3	5	2

**MWAT data from MSG summertime temperature logger placement. Sediment, Flow, and Wood and/or Complexity ratings determined from MSG, Sanctuary Forest (SFI), and MRC data, anecdotal information, and MSG, SFI, and MRC staff review.*

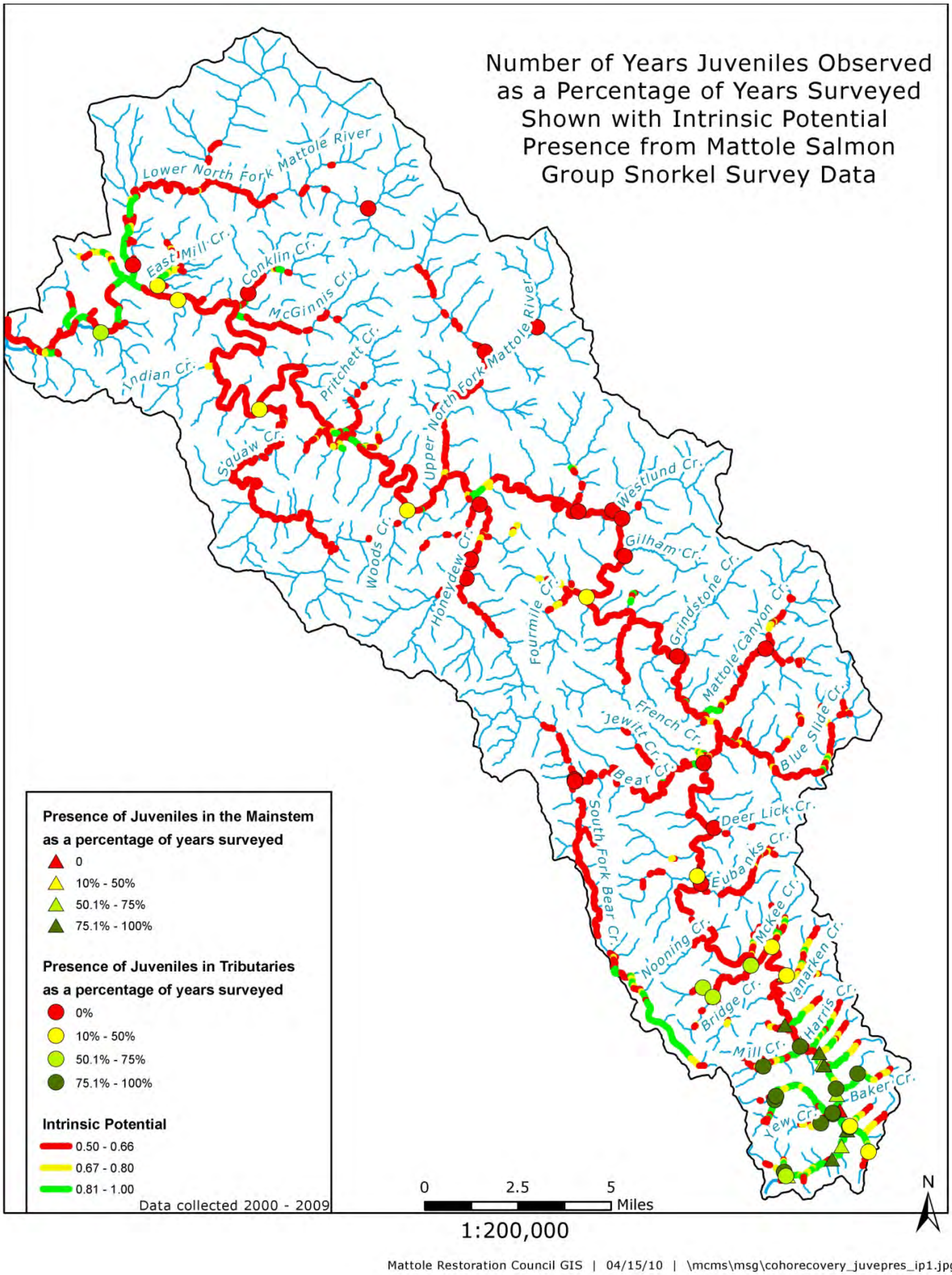


Figure 32. Intrinsic potential of coho habitat compared with juvenile presence as a percentage of years surveyed throughout the Mattole River watershed, MSG snorkel survey data, 2000-09.

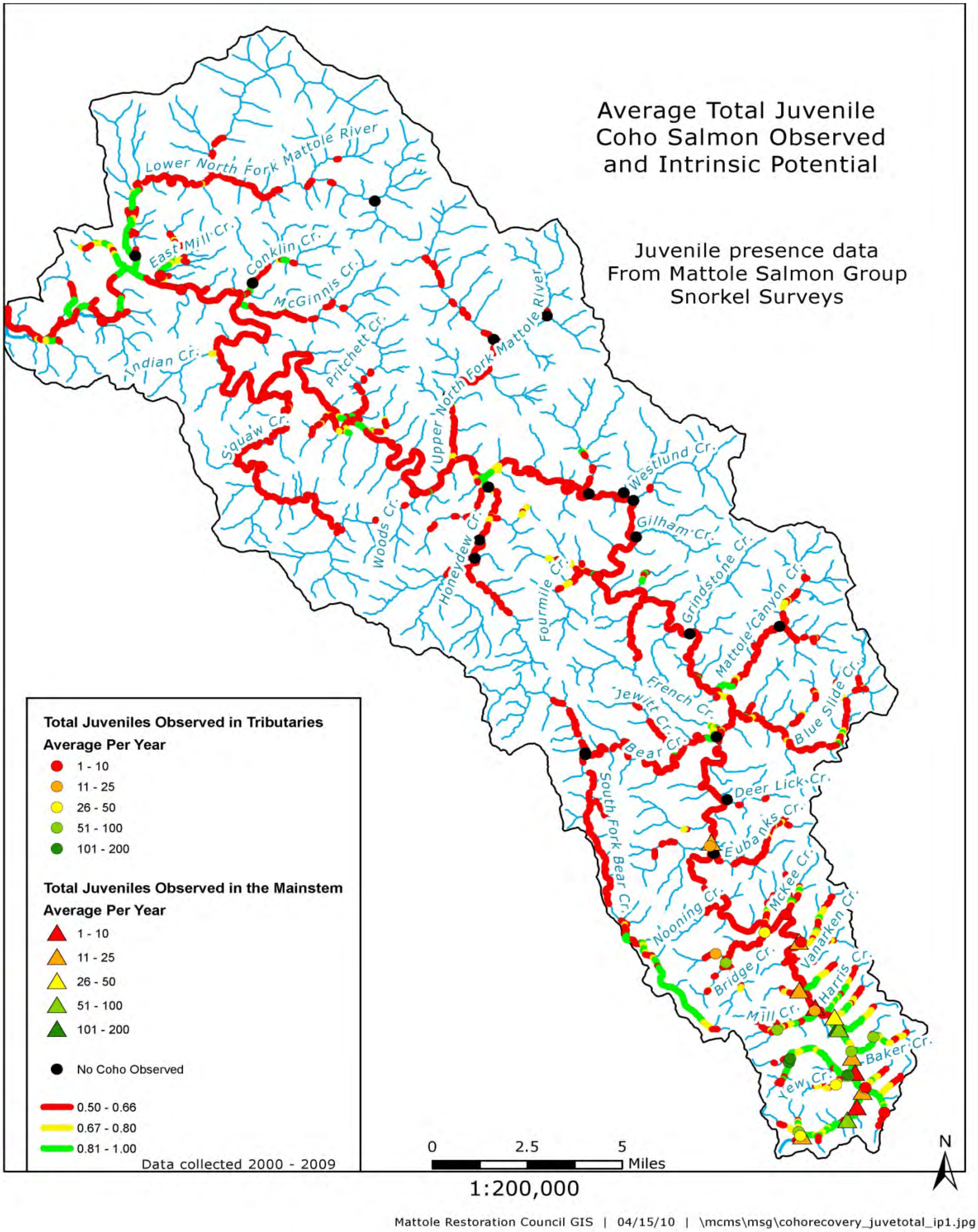


Figure 33. Intrinsic potential of coho habitat compared with numbers of juveniles observed throughout the Mattole River Watershed, MSG snorkel survey data, 2000-09.

3. Data Gaps

Dive surveys occur throughout the watershed in order to determine presence of coho salmon using a modified 10-pool protocol. This survey method, however, is not used to determine abundance of juvenile coho salmon, although inferences of increasing or decreasing abundance can be made over time (i.e. relative abundance). Adequate property access and funding do not exist to determine accurate juvenile abundance throughout the watershed via dive surveys.

While significant juvenile mortality due to low flows was documented in 2007 and 2008 in selected reaches, it is unknown what percentage of the total juvenile population these mortalities represent. While it is evident that the inter-related factors of low summertime streamflows, high water temperatures, low DO concentrations, and a lack of complex habitat and cover are responsible for high summer mortality rates. The influence of these factors on reduced growth and poor winter survival remains unknown.

Also largely unknown is the amount of juvenile mortality attributable to inadequately screened diversions in the Mattole headwaters. A survey conducted in 9.4 miles of the upper mainstem in 2004 documented 48 pump intakes with only two of these diversions containing screens that met CDFG criteria (McKee 2004b). Although some diversions have since been replaced with acceptable screens, it is unknown how many inadequately screened diversions still exist in the watershed. Given the likelihood that this number is high, the threat these diversions pose to coho salmon may be significant.

4. Research from Other Watersheds

The Mattole contains very low densities of juvenile coho when compared to other regional watersheds. Densities in 2007 and 2008 in Lagunitas Creek, Redwood Creek (Marin County), and Olema Creek were 0.06-0.63 fish/m^2 (Ettlinger et al. 2009a), 0.52 fish/m^2 (mean), and 0.97-1.3 fish/m^2 (Carlisle et al. 2008), respectively. For those same years, juvenile coho densities in pools in the Mattole headwaters and selected headwaters tributaries were a mean of 0.019 fish/m^2, with a maximum density of 0.11 fish/m^2 in 2007 and 0.24 fish/m^2 maximum in 2008 (Grantham 2008). These low densities are evidence of the low adult returns over the past few years. They may also indicate poor survival and high displacement during the fry life stage.

Coho over-summer survival estimates from other watersheds range from 9-75%, with most estimates around 40% (Brakensiek 2002, May and Lee 2004, Obedzinski et al 2008). While all but one of the 2007 and 2008 coho over-summer survival estimates in the Mattole fall within this range (Table 10, pg. 59), the Mattole estimates encompass a single month, whereas the above estimates are from June – October.

While much of the recent literature regarding coho growth and survival focuses on winter conditions, there has also been research from other watersheds in the southern end of the range of coho that has documented the effects of low summer flows on coho juveniles. In the Oregon Coast Range, lower summertime growth rates have been correlated with low summertime flows, due to reduced habitat quantity (Ebersole et al. 2009b) and reduced food availability caused by the absence of macroinvertebrate drift in disconnected pools (May and Lee 2004). Food availability appears to be a major factor in determining oversummer mortality and condition (Obedzinski et al. 2008). With warmer temperatures, fish metabolize more quickly and need to intake more calories to amass (or maintain) an equivalent amount of body weight.

Low flows have also been implicated as a significant source of mortality due to increased predation efficiency or outright desiccation in the Smith River Watershed's Mill Creek (Stillwater Sciences 2006, Fiori et al. 2010), Scott Creek (Smith 2001), Russian River tributaries (Obedzinski et al. 2009), and the Oregon Coast Range (May and Lee 2004).
Low flows and disconnected pools can contribute to poor water quality conditions, including potentially lethal DO concentrations, which have been documented in Lagunitas Creek (Pincetich et al. 2009). Similar conditions have been found in the Mattole, where MSG headwaters monitoring documented DO levels below the lethal level of 3 mg/L (Spence et al. 1996) in four out of six years monitored. High water temperatures have also been shown to limit habitat availability in the Oregon Coast Range (Ebersole et al 2009b), and have been correlated with reduced rates of over-summer survival in Russian River tributaries (Obedzinski et al 2008).

Other studies have found that intermittent streamflows are not necessarily lethal for oversummering juveniles, provided that certain habitat requirements are met or supplemented. In coastal Oregon, Wigington et al. (2006) documented residual pools fed by groundwater inputs with constant cool temperatures where juvenile coho oversummered with success. The differences between the conditions documented in this study and the Mattole needs to be understood, and are likely related to the amount of hyporheic or groundwater inputs to disconnected pools, the degree of competition for food and space, and the duration of stressful conditions (e.g. length of dry season).

While generally coho are thought to out-compete other salmonids for food and space (Lestelle 2007), the high density of rearing steelhead relative to coho juveniles raises questions about competition when streamflows are low and the available rearing space shrinks. In a study in Caspar Creek (Mendocino County), high steelhead densities appeared to suppress coho growth in late summer (Harvey and Nakamoto 1996). The researchers concluded that as the total rearing space shrinks and fast-water habitat disappears, there is no possibility for habitat portioning amongst the species. In the Mattole, an abundance of 1+ or older steelhead that are larger than YOY coho may compete for food and space more effectively with coho than YOY steelhead. With the loss of large wood and decrease in habitat complexity and slack water habitat in streams in the Mattole headwaters, the habitat suitability for steelhead may have increased at the expense of coho rearing.

Summertime movement can affect the percentage of the population lost to stranding-related mortality. Studies in Prairie Creek (Brakensiek 2002) and the Smith River watershed's Mill Creek (Fiori et al. 2010), however, found little movement during summertime low-flow periods. Fiori et al. (2010) speculated that as streamflows diminished, riffle velocities and shallow depths prevented juveniles from emigrating to avoid stranding. On the other hand, studies in small western Washington streams have found quite different results. Kahler et al. (2001) recorded extensive movement by juveniles – most of it in the upstream direction – as streamflows diminished. Fish that moved exhibited higher growth rates than non-movers. The authors further speculated that high densities of non-movers observed in residual pools may have been a consequence of a fish's reluctance to leave high-quality habitat, and that high density may afford protection at the expense of growth.

Movement in the downstream direction has been documented in nearby watersheds, as well. In Redwood Creek (northern Humboldt County), juvenile coho are commonly observed in the estuary in the spring prior to closure of the river mouth, and there is historical evidence that coho juveniles used the lower mainstem for summer and winter rearing (Cannata et al. 2006). In the Klamath River, a significant redistribution of YOY in June and July is common, as flows decline and water temperatures rise (Sutton and Soto 2010, Hillemeier 2009). Some of these fish spend the rest of the summer in the mainstem Klamath where cool tributary inflows provide thermally suitable habitat, while others have been observed to ascend thermally suitable tributaries, covering distances that range from hundreds of feet to a few miles. Fish that do not find thermally suitable habitat appear to continue to move in search of it throughout the summer (Sutton and Soto 2010, Hillemeier 2009). This phenomenon has inspired efforts to increase juvenile access to Klamath River tributaries in the summer, many of which currently have very aggraded deltas that go dry or have excessive velocity and insufficient depth to allow fish access (Beesley and Fiori 2007)

Downstream re-distribution may be an expression of a specific life history strategy identified by Koski (2009) in his extensive review of literature concerning juvenile coho rearing. Koski (2009) suggests that after emergence, coho juveniles may move downstream to warmer areas with a larger food supply. He identifies the area in the upper estuary between the tidal-fresh and the tidal-brackish transition zone (called the stream/estuary ecotone) not only as an area with abundant food, but also as an ideal habitat for salmon to osmotically acclimate to marine conditions. Juvenile rearing in this ecotone can also result in dramatically increased growth rates, with 50% of estuary-reared YOY containing the same biomass as one-year-old smolts (Koski 2009). Koski's study focused on streams ranging from southern Oregon to southeastern Alaska. While, admittedly, estuarine temperatures may be quite different in these streams than in the Mattole, the conclusions of his findings in regard to the importance of restoring estuarine habitat and preserving alternate coho life history strategies should hold no less merit.

Low summertime growth rates may be one factor lending to the hypothesis that a portion of Mattole juvenile coho rear for two years in freshwater. MSG staff have occasionally observed coho salmon >100 mm during fall dive surveys and measured fork lengths of >140 mm at the lower mainstem DSMT. These figures are similar to numbers gathered by Bell and Duffy (2007) on Prairie Creek. Bell and Duffy (2007) found that, in general, coho salmon would remain in freshwater for a second year if they were smaller than 75 mm by late in the spring of their first year. Scale analysis of coho salmon in that system documents a percentage of two-year old fish with a mean fork length of 101.9 mm, while the one-year-old fish had a mean fork length of 88.6 mm (Bell and Duffy 2007). The slower growth was determined to be due to a large number of juveniles that particular year or poor habitat quality.

5. Summary

Potential factors limiting survival of coho juveniles during the summer include water quantity, water quality (dissolved oxygen, temperature), and availability of properly functioning habitat, which, if low, can create competition for food and space, and can also increase predation.

Under current conditions, juvenile coho in the Mattole are thermally restricted to summer rearing in the headwaters and headwaters tributaries. These same areas, however, are the most impacted by low summertime flows that negatively affect water quality and quantity, and reduce the availability of optimal habitat. Low flows resulting in shallow riffle depths and disconnected pools can restrict the ability of juveniles to move to better habitat, which in turn can increase competition and predation. Extreme low flows in 9 out of the last 11 years have been observed to cause direct mortality of juvenile salmonids trapped in disconnected pools – many of which completely dry. Given the influence of adequate water supply and flow on summer rearing habitat conditions, we conclude that instream flows are currently the primary limiting factor to juvenile coho oversummer survival in the Mattole River Watershed. Outside of the headwaters, temperature and lack of complex habitat appear to be the most limiting to survival.

E. Juvenile/Smolt Outmigration

1. Habitat Requirements

Success of coho outmigration is influenced by water quantity, habitat complexity, water temperature, and predation. The degree to which any of these factors plays a key role in coho growth and survival depends largely on how quickly outmigrants move through the river system, and also the extent to which they are actively feeding. Optimal temperature ranges for emigration are between 2.6-13.3˚C (36.6-55.9˚F). Refugia such as undercut banks and wood accumulations are also important protective habitats for migrating coho (CDFG 2002).

2. Habitat Conditions

As mentioned previously, habitat in the middle and lower Mattole mainstem and estuary is severely degraded; there is little flow refuge and cover is limited. It seems likely that the floodplain forest was once considerably more extensive along the alluvial reach of the Mattole from Honeydew Creek downstream to the ocean. This forest would have been a significant source of wood inputs through bank erosion and would have encouraged a more complex channel with increased anastomosis (braiding), side channels, and sloughs.

These alluvial areas, however, were the most desirable to Euro-American homesteaders, and were the first areas of the watershed to be cleared for grazing and agricultural use. This is evidenced by the earliest photos taken of the Mattole estuary and lower mainstem, circa 1900, after 40 years of settler activity. This already-disrupted lower Mattole ecosystem was further degraded by the major land disturbances of the 1940s-70s, mentioned previously. Before these activities, the estuary and stream/estuary ecotone contained several functional slough habitats. Currently, the lower mainstem Mattole and estuary have relatively few sloughs, backwaters, and side-channels to provide habitat for outmigrants. The lack of off-channel habitat in the estuary may be of particular importance for coho smolts.

Presently, water temperatures in the mainstem Mattole pose a serious threat to outmigrating coho juveniles, as they are persistently above the 16.7˚C (62.06˚F) thermal stress threshold. For example, 2008 MWATs at most monitored locations in the mainstem from RM 35 downstream to the mouth exceeded 16.7˚C in the first week of May (Baier 2008). The seasonal nature and timing of this crucial limiting factor (temperature) may greatly influence juvenile outmigration and the timing thereof.

While it is possible to generally determine the peak outmigration period in some years, the actual numbers of coho caught are too few to allow for statistically valid outmigrant population estimates. Regardless, the MSG measures fork length on all coho smolts that are caught, in order to gain some insight on the health of the outmigrant population and to recognize trends over time. The average fork lengths of coho salmon smolts (excluding any YOY) captured in the lower mainstem DSMT in recent years have been noticeably lower than average fork lengths from 1997-2002, with the exception of 2010 (Table 12; coho were counted but not measured in 2003). While, beginning in 2006, trapping efficiency apparently increased and more coho were caught in the DSMT (with the exception of 2010), changes in trapping timing or methodology do not immediately explain this phenomenon.

Although data are limited, the coho smolt fork length data that do exist provide evidence that rearing habitat may not allow for optimal growth of coho salmon. Discussion of this evidence can be found below in *Research from Other Watersheds* (section III.E.4).

Table 12. Coho smolt data from the lower mainstem DSMT (RM 3.9), Mattole River, 1997-2010.

Year	Commencement Date	Number of days trapped	Number of coho smolts captured	Smolt Average Fork Length	Standard Deviation
1997	May 24	30	11	105.36	8.51
1998	April 16	56	158	109.13	8.51
1999	April 23	38	25	104.08	10.20
2000	May 16	26	5	108.40	7.89
2001	May 3	57	29	110.21	8.87
2002	May 7	46	10	103.60	9.34
2004	May 4	35	17	99.82	8.06
2005	May 13	36	53	102.25	7.16
2006	May 3	58	469	97.90	8.70
2007	April 9	64	218	101.68	12.10
2008	April 10	72	318	101.07	8.97
2009	April 24	57	215	102.88	9.73
2010	April 21	92	3	108.33	9.71

3. Data Gaps

Late-winter and spring flows in the Mattole often deter mainstem outmigrant trap installation until after the beginning of the coho migration period. Although we are able to determine peak outmigration timing in years where hundreds of coho are caught (late April/early May; 2006-09), it is impossible to determine this timing in years when few are captured.

During past trapping efforts, average daily coho catch has ranged from 0-8 individuals, with a combined daily average of 1.66 fish per day at the lower mainstem SMT from 1992-2010. These low numbers are inappropriate for statistical mark-recapture studies due to the disproportionate effect that a single marked fish would have on the efficiency estimate. Ideally, enough fish should be marked and released with the goal that one recaptured fish will not alter the efficiency estimate by more than 5% (USFWS 2008). In 2006, due to the large number of coho captured, there was an attempt to conduct coho mark recapture studies. However, because numbers only remained sufficiently high for part of the season, a Chinook efficiency estimate was substituted for the remainder of the season. Due to the difficulty in making a scientifically valid population estimate from the low numbers of coho caught, trap efficiencies using coho were not conducted in other years. As a result, outmigrant data is not used to generate an abundance estimate, but rather to compare trends and assess fish health and growth.

In addition, the extent of predation on migrating smolts is, as of yet, undocumented in the Mattole. It is probable that the limited habitat complexity in the middle and lower mainstem increases predation pressure on outmigrants, as available cover is lacking and distance to what little cover exists may be great.

4. Research from Other Watersheds

Peak migration periods in other coastal California streams range from mid-April to mid-May (Sparkman 2009, Ricker 2006, Ricker 2008, Stillwater Sciences 2009, Obedzinski et al. 2008, Pincetich et al. 2009, Weitkamp et al. 1995), which are comparable to the Mattole. However, in 2008 and 2009 in Lagunitas Creek, Stillwater Sciences (2009) documented an additional peak of outmigrants during the first week of trapping in early March. This observation may be an anomaly for that year, as the study notes, "Typically, and as we observed in Lagunitas Creek in 2006 and 2007, outmigration of coho smolts follows a bell-shaped curve beginning with low levels of migration in early March, increasing to a peak during late April/early May, and ending in early June ...".

As noted previously, rearing habitat conditions may be resulting in a lower growth rate for juvenile coho in the Mattole when compared to other watersheds. With the exception of Freshwater Creek, Mattole coho salmon outmigrants appear to be smaller than coho in similar watersheds (Table 13). Data from Redwood Creek document mean annual 1+ coho smolt fork lengths from 2004 to 2008 as 105.3, 109.4, 105.7, 104.9, and 109.1 mm, respectively (Sparkman 2009). In Freshwater Creek, smolt mean fork lengths at the lower mainstem trap were 100 mm and 98 mm in 2005 and 2008, respectively (Ricker 2006, Ricker 2008). Coho salmon outmigrant fork lengths in Lagunitas ranged from 66-145 mm with a mean of 106 mm in 2009 (Stillwater Sciences 2009). Trapping efforts in San Geronimo Creek (a Lagunitas Creek tributary) have recorded fork lengths from 2006 to 2009 of 110.8, 110.5, 106.7, and 109.9 mm, respectively (Pincetich et al. 2009, Pincetich et al. 2010). Similarly, the National Park Service found a mean smolt length in Olema Creek from 2004 to 2007 of 109.89 mm (Carlisle et al. 2008)).

Table 13. Comparison of coho smolt outmigrant fork lengths from various California coastal watersheds.

Watershed	Data Collection Period	Average Fork Length (mm)
Mattole River	2006-2010	100.30
Redwood Creek (Marin County)	2004-2008	106.88
Freshwater Creek	2005, 2008	99.00
Lagunitas Creek	2006-2009	108.78
Olema Creek	2004-2007	109.89

While most coho smolts caught at the Mattole lower mainstem trap appear to be smaller than those of neighboring watersheds, capture of smolts with fork lengths >140 mm have occurred. As mentioned previously (section III.D.4), this may be indicative of a two-year freshwater rearing cycle, as these larger fork lengths are similar to those found for two-year-old coho in Prairie Creek (Bell and Duffy 2007).

While spring outmigration of coho smolts has often been considered a rapid process from natal stream to the ocean, recent evidence suggests that fish may spend a few weeks or months moving from natal habitat to salt water, even in relatively small river systems (Lestelle 2007). Additionally, there is increasing evidence that quality and quantity of estuarine habitat is important in the physiological transition juveniles undergo during the process of smoltification (Lestelle 2007).

5. Summary

Water quality conditions – specifically temperature – in the mainstem Mattole can become unsuitable for coho smolts in late spring. As described previously (section III.D.2), the middle and lower Mattole mainstem lacks habitat complexity, cover from predation is scarce, and food availability may be limited. The Mattole estuary also exhibits these same constraints to salmonid survival. Smolts may have very little time (due to lack of cover and suitable habitat) to undergo the osmotic transition necessary for successful ocean survival. Ideal habitat that would facilitate this transition process, such as sloughs and off-channel ponds, are non-existent in the estuary. Based on lack of suitable refuge habitat in the middle and lower Mattole mainstem and estuary, we conclude that coho outmigrants move downstream as quickly as possible during their journey to the ocean. Low habitat complexity appears to be the main limiting factor for coho smolt survival during outmigration.

F. Adult Ocean Migration

1. Habitat Requirements

Upon ocean entry, young coho salmon remain close to shore, gradually moving farther offshore as they increase in size. Survival of adults in the ocean depends heavily on ocean conditions relating to upwelling strength and sea surface temperatures. As coho salmon are generally found within the uppermost 30 meters of the ocean, changes in sea surface temperatures may greatly affect adult ocean survival. Ocean conditions have a significant impact on the overall production of all species of Pacific salmon (Francis 1999). Climate and ocean variability act on a number of time (seasonal, annual, and decadal) and spatial (global, regional, and local) scales to affect salmon production dynamics. Other factors that affect survival are size and condition at outmigration, predation, and fishing pressure, whether directly or as bycatch.

Salmon have responded to climate and ocean-driven uncertainties for millennia by evolving diverse life history strategies such as mixed year-classes, extended juvenile freshwater rearing, nomadic estuarine rearing, extended smolt migration periods, and long adult spawning migrations, among others.

2. Habitat Conditions

Poor ocean productivity off the California coast is believed to play a major role in the declines of 2007-08 and 2008-09 cohorts of California coho. In the Mattole, these cohorts declined 68% and 46%, respectively, based on escapement indices. These figures were comparable with regional declines, and generally less extreme than those observed in populations south of the Mattole (MacFarlane et al. 2008, Ettlinger et al. 2009b). While we do not have consistent smolt-to-adult survival rates for the Mattole, it seems clear that ocean survival has had a large effect on escapement in the Mattole in recent years.

Decreased ocean productivity may be due in part to phase changes in the Pacific Decadal Oscillation (PDO), a 30-year phenomenon that affects the northern Pacific Ocean. Changes in the PDO can affect wind speed and direction, sea surface temperatures, deep-water temperatures and salinity, and upwelling. If coastal waters are mostly warm and fresh during the late spring (when coho enter the ocean), upwelling is diminished and coho salmon survival is poor. However, if continental shelf deep source waters are relatively cold and salty upon smolt ocean entry, then upwelling may be more dramatic, and coho salmon survival is predicted to be high. The timing of upwelling also affects coho survival; NOAA's Northwest Fisheries Science Center has found strong correlations between April and May upwelling and good coho salmon survival (www.nwfsc.noaa.gov/research/divisions/fed/oeip/aecinhome.cfn).

Although commercial salmon fishing is closed for coho salmon in California coastal waters, a limited amount of bycatch does occur. Estimated fleet-wide bycatch in the West Coast 2008 nearshore groundfish fishery was 39 coho. Estimated 2008 bycatch for all Pacific hake fishery sectors is 52 coho (Bellman et al. 2010). These numbers may initially seem inconsequential, but their significance increases when taking into account that only 3 live adults were observed in Mattole River spawner surveys in 2009-2010. Loss of coho as bycatch legitimately poses a threat to Mattole coho, so as long as their numbers continue to remain drastically low.

As mentioned in the *Juvenile Summer Rearing* and *Juvenile/Smolt Outmigration* sections, coho salmon are outmigrating from the Mattole at a relatively small size compared to other regional watersheds. Entering the ocean at shorter fork lengths is generally thought to reduce the chance of ocean survival. In Scott Creek, scale analyses from returning adults showed that no outmigrant fish with fork lengths less than about 110 mm returned as adults (Hayes 2010). Data from the Mattole from 2002 and 2004-09, however, document rather low percentages of coho outmigrating at lengths greater than 110 mm (Figure 34).

The small size of Mattole coho outmigrants is most likely due to poor freshwater rearing habitat conditions. Unfortunately, because of this limitation in size, those salmon that do make it to the ocean may already be severely handicapped in their ability to endure poor ocean conditions.

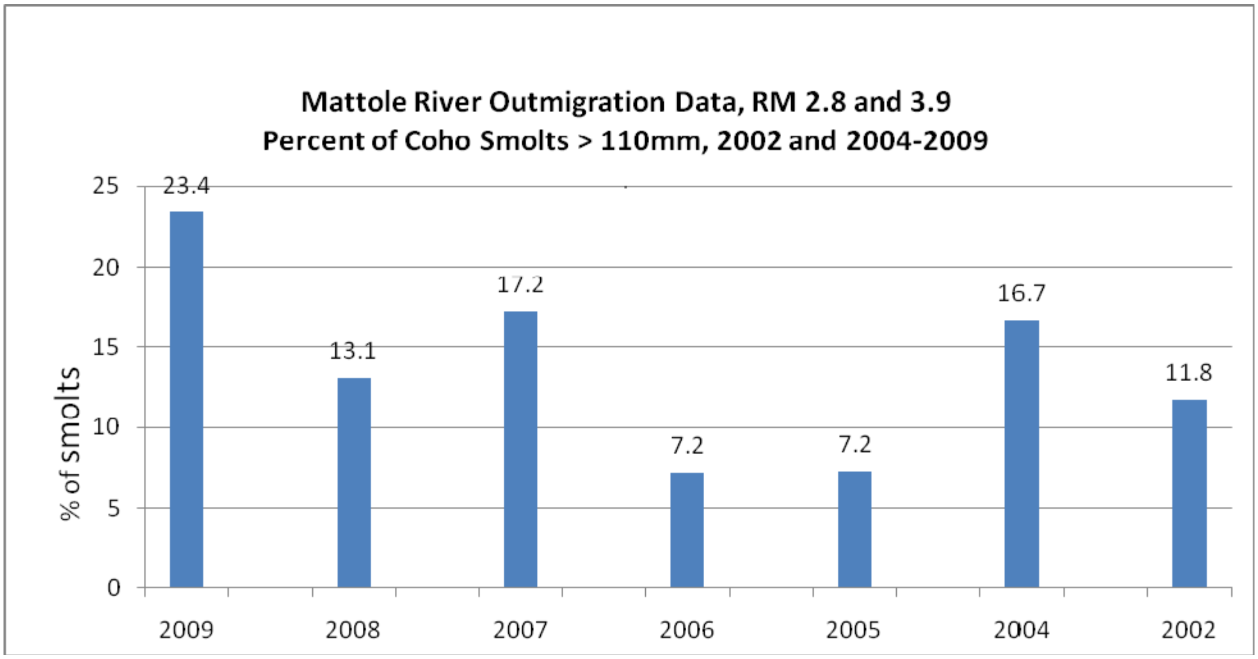


Figure 34. Percentage of outmigrant coho smolts greater than 110 mm in the Mattole River.
Note: data collected from MSG 1.5-m rotary screw trap operations, RM 2.8 and 3.9, 2002 and 2004-2009.

3. Data Gaps

Lacking consistent smolt population estimates, Mattole smolt to adult survival rates for most spawner years are unknown. Oceanic conditions, such as productivity and temperature, do affect marine survival and drive fluctuations in coho salmon escapement (Beamish et al. 2000; Logerwell et al. 2003), although the degree to which these conditions specifically affect the Mattole coho population is unknown. The quantitative effects of predation on coho are also unknown, although adults are eaten by sharks, sea lion, seals, and orcas (http://www.nmfs.noaa.gov/fishwatch/species/coho_salmon.htm). Despite the specific unknown contributions of each factor affecting survival, coho salmon marine survival rates have been determined for some populations. This rate averages about 10 % (Bradford 1995), although there is a wide range in survival rates (from < 1% to about 21%) depending upon population location and ocean conditions (Beamish et al. 2000, Quinn et al. 2005).

4. Research from Other Watersheds

Recent smolt-to-adult survival rates have been very low along the Northern California coast. In Marin County streams, smolt-to-adult survival from 2006 outmigrants to 2007-08 adults ranged from 0.0-0.31% (Carlisle et al. 2008), and in Mendocino County streams (Pudding Creek, Caspar Creek, Noyo River) this ranged from 0.1-2% (Gallagher and Wright 2008). Survival for the following cohort was similarly dismal, with Lagunitas Creek smolt-to-adult survival at 2% (Ettlinger et al. 2009b). The 2006 Mattole coho outmigrant population estimate of 4,922 ± 2,510 in conjunction with the 2007-08 minimum escapement estimate of 62 coho (based on 31 coho redds) yields a minimum marine survival rate of 0.8-2.5%. This is comparable to the aforementioned regional values.

There is also some coherence in escapement trends between the Mattole and the southernmost self-sustaining CCC coho populations (Figure 35). General declines of returning adult coho in multiple watersheds may signify that poor ocean conditions account for a large percentage of the declines observed along the entire California coast (MacFarlane et al. 2008, Ettlinger et al. 2009b).

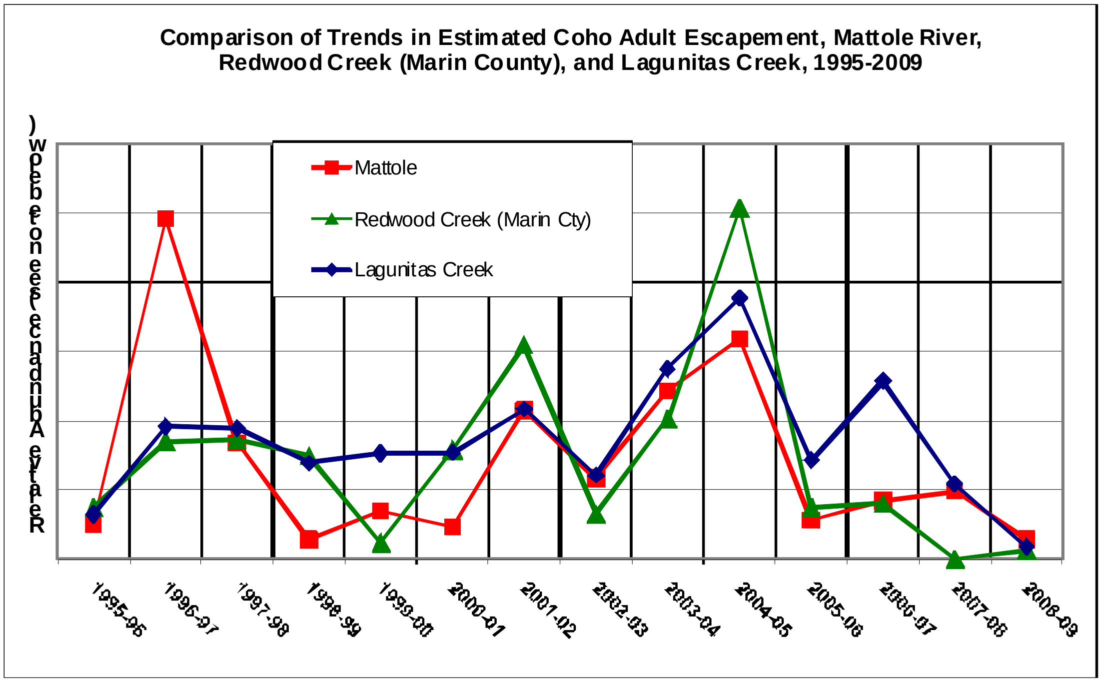


Figure 35. Trends in coho escapement from the Mattole River Watershed and other California coastal watersheds.
Note: data were scaled to facilitate comparison of trends over time, so this graph shows relative abundance and should not be used to compare total populations between watersheds. Original data used different methods as a means of tracking escapement: EI (coho redds/mile surveyed - Mattole), PLD (Peak Live plus cumulative Dead) min. escapement (Redwood Creek) and total redds (Lagunitas). Marin County Redwood Creek data from Carlisle and Reichmuth (2009). Lagunitas Creek data from Ettlinger et al. (2009b).

5. Summary

Ocean conditions since about 2004 appear to be generally unfavorable for the smolt to adult survival of California coho (MacFarlane et al. 2008 and Ettlinger et al. 2009b) and may be the most influential limiting factor for adult returns. However, smolt size and condition upon ocean entry can also significantly affect marine coho survival. While restoration efforts in the watershed have little direct effect on ocean conditions, they can produce freshwater conditions favorable to increased smolt growth rates and size upon ocean entry, which help to ameliorate the effects of poor or unpredictable ocean conditions. “In order to preserve the capacity of Pacific salmon to respond to variable ocean conditions, we must preserve and restore intact and connected freshwater and estuarine habitat. Once this point is firmly institutionalized, the salmon will do the rest” (Francis 1999).

G. Summary of Mattole Limiting Factors

Table 14 lists the factors we believe to be most limiting coho salmon survival in the Mattole River watershed. First and foremost, it should be acknowledged that the population is now so low, it is unable to effectively respond to poor habitat conditions or even naturally fluctuating environmental factors, such as drought and ocean conditions. While the cumulative impacts of multiple factors have resulted in the decline of the population, we believe two key factors are currently most limiting to survival and abundance: low instream flows and the lack of complex backwater or off-channel habitat offering refuge from stormflows. These two conditions are the primary drivers for many of the other impairments enumerated in this document, and are also factors that can be addressed through restoration actions. If these factors are not addressed immediately, within the milieu of a fading population, coho salmon in the Mattole may not endure, let alone recover. However, all listed limiting factors must be addressed throughout the watershed for the population to recover above the depensation level of 250 adults, and then to exceed the minimum viability level of 6,500 adults.

Table 14. Factors limiting survival of coho salmon in the Mattole River Watershed.

Life Stage	Activity	Timing	Factors Most Limiting Survival	Further Research Warranted
Adult	Migration & Spawning	November-January	Finding a Mate	Flow (rainfall timing), Poaching
Egg & Alevin	Incubation & Emergence	November-March	N/A	Flow (rainfall timing), Predation
Fry	Winter Rearing	March-June	Flow Refuge, Habitat Complexity	Fish movement
Juvenile	Summer Rearing	June-October	Instream Flows, Temperature, Habitat Complexity	Fish movement
Juvenile	Winter Rearing	October-March	Flow Refuge, Habitat Complexity	Fish movement
Juvenile/Smolt	Outmigration	March-June	Habitat Complexity	Determination of peak migration timing, Population estimates
Adult	Ocean Migration	April - the following December	Ocean Conditions, Size upon Ocean Entry	Ocean conditions

IV. Implementation of Recovery Actions

A. Introduction

Based on the current understanding of the quality of instream habitat, habitat utilization, and coho life history in the Mattole, we have prioritized restoration actions and stream reaches in which we believe these actions should be implemented. In addition to outlining specific strategies and tributaries/stream reaches, this section also outlines necessary and recommended funding and permitting actions that are needed due to the emergency state of coho salmon in the Mattole River Watershed and in California populations, in general.

The *Strategies for Recovery* section below outlines the actions most important to restore coho salmon habitat and populations in the Mattole. Strategies are divided into two tiers. Tier 1 strategies are those we believe are necessary to implement immediately to prevent extirpation of coho salmon from the Mattole River Watershed. These strategies directly address the factors we have concluded to be most responsible for the continued decline of coho salmon populations (i.e. most limiting to Mattole coho salmon survival). These strategies are primarily focused on alleviating extremely low summertime flows, and providing greater flow refuge and habitat complexity in winter and spring, as well as addressing the exceptionally fragile state of the population. In most cases, a positive response in habitat quality from the implementation of Tier 1 strategies should occur fairly rapidly. Tier 2 strategies will be necessary to increase the abundance and distribution of coho salmon in the Mattole over the long-term, but are less directly linked to the most important factors currently threatening the population with extinction. Improvements in habitat from these actions may not be manifested for decades.

Our *Strategies for Recovery* overlap with tasks outlined in the *Mattole Integrated Coastal Watershed Management Plan* (MICWMP) and CDFG’s *Recovery Strategy for California Coho Salmon* (CDFG 2004). Table 15 correlates the strategies with the tasks and associated information outlined in each of these documents. Appendix C of this document contains further information on work completed to date in the Mattole to address the recommended actions in the *Recovery Strategy for California Coho Salmon.*

Table 15. Correlation of MCRS Tier 1 and Tier 2 Strategies with MICWMP and CDFG's *Recovery Strategy for California Coho Salmon* (CDFG 2004) Tasks.

Strategy	**MICWMP Tasks**	**MICWMP Pages Outlining Tasks**	**MICWMP Pages Providing Background Information**	**CDFG *Recovery Strategy for California Coho Salmon* Tasks**
Tier 1 Strategies				
Water Storage Tanks & Forbearance Agreements	WQ-1, WQ-2, WQ-3, WQ-5, WQ-9, WQ-10, WQ-23, WQ-27,WQ-29, FR-4	86-97, 99	26-28, 52-54, 62-73, 126-128	CM-MS-01, CM-MS-10, MS-14, CM-MW-14
Groundwater Recharge, Large Wood Structures for Streamflow Enhancement, & Wetland Enhancement	WQ-7, WQ-8,WQ-9, WQ-18, WQ-23, WQ-28, WQ-29, WQ-35	87-97, 99	62-73, 126-128	CM-HU-01, CM-MS-20
Recovery Rearing	FR-1	98	N/A	N/A
Instream Habitat Enhancement	FR-6, FR-7, FR-8, RER-3	99-100, 109	33-35, 62-64, 72-73	CM-HU-01, CM-HU-04, CM-MW-01, CM-MW-02, CM-MS-20
Properly Screening Water Diversions	Not explicitly included in MICWMP	N/A	N/A	N/A
Tier 2 Strategies				
Reduce Sediment Inputs	SM-1 through SM-5	103-104	118-119	CM-HU-02, CM-HU-03, CM-MS-05, CM-MS-06, CM-MW-03, CM-MW-05, CM-MN-02, CM-ME-01, CM-ME-03, CM-ME-04
Riparian Ecosystem Restoration	FR-6, FR-8, RER-1 through RER-4	99-100, 108	33-35, 62-64, 119-123	CM-HU-01, CM-HU-04, CM-MS-15, CM-MS-19, CM-MW-01, CM-MW-03, CM-MW-05, CM-MW-06, CM-MW-10, CM-MN-01, CM-MN-02, CM-ME-02, CM-ME-03
Land Acquisition/ Conservation Easement	LC-1 through LC-5	115-117	65	CM, MS-02, CM-MS-03, CM-MS-14, CM-MW-15
Forest Management	WQ-32	96	59-60, 64, 126-127	CM-HU-01, CM-MS-20
Groundwater Infiltration Restoration	WQ-15	91	67-69	N/A
Education & Watershed Stewardship	WQ-4, WQ-5, WQ-15, WQ-17, WQ-21	87-88, 92-93	131, 163-164	CM-MS-01, CM-MS-11 CM-MS-15, CM-MW-07, CM-MW-09, CM-MW-11, CM-MW-13

The second sub-section, *Prioritization by Tributary/Stream Reach*, places streams and stream reaches in four priority categories based on coho salmon presence, current habitat quality, projected habitat response, and the feasibility of project implementation. Applicable strategies for each tributary/stream reach are specified in both text and tables. Some of the strategies, such as education and outreach, are not listed in the tables since they do not have an explicit spatial component.

Many of the strategies below are components of ongoing restoration programs carried out in the Mattole by county, state, and Federal agencies, private landowners, and the MRRP. With few exceptions (see the prioritization tables below), in this document we have not provided specific information on the spatial location or extent of previously completed restoration projects. For a history of previous salmon recovery efforts in the Mattole, refer to the *2005 Mattole Watershed Plan* (MRC et al. 2005), the *Mattole River Watershed Assessment Report* (Downie et al. 2003), the Fisheries, Riparian Restoration, Sediment, and Education Monographs of MICWMP (MRRP 2009a, 2009b, 2009c), and Appendix C of this document.

There are strategies that we have not highlighted here that, while less directly connected, will ultimately enhance the chances of coho survival in the Mattole. MICWMP provides information on the broader scope of MRRP watershed restoration efforts over the next decade.

Over the long term, placing logs in the creek and upgrading culverts will not sustain a thriving coho salmon population in the Mattole. The survival of coho depends on the functioning of ecosystem processes – growth, decay, fire, and flood - throughout the watershed in a manner approximating that with which the fish co-evolved. Of equal importance is a human community committed to land stewardship, conducting their activities in consideration of the potential for positive or negative outcomes for salmon.

B. Strategies for Recovery

1. Tier 1 Strategies: Necessary to Avoid Extirpation

a. Water Storage Tanks and Forbearance Agreements

i. Primary Limiting Factors Addressed

The Mattole Tank and Forbearance Program will address factors related to juvenile summer rearing. Low summer flows and the complete drying of entire stream reaches results in direct mortality from chronic and acute stresses, including pool drying and desiccation, sub-optimal rearing conditions related to poor water quality (specifically DO), crowding and reduced availability of forage, and increased risk of predation.

ii. Description of Action

Following unprecedented low flows in the headwaters of the Mattole in the summer of 2002, a water conservation program was launched in the watershed led by Sanctuary Forest (SFI). Analyses suggests that climate change and a longer dry season are the main driving forces of the low-flow problem, with human use, high evapotranspiration rates and a loss of groundwater storage exacerbating the problem (Klein 2009, Klein 2007, McKee 2004a).

SFI's Tank and Forbearance Program provides financial and technical assistance to develop water storage for landowners whose primary water source is a coho-bearing stream in the Mattole headwaters. In exchange for this assistance, landowners sign a legally binding forbearance agreement that prohibits them from drawing water during a designated critical low flow period for 15 years.

Through 2010, ten landowners have been enrolled in the program, and another ten landowners have signed agreements to enroll, pending funding. Since the program's inception, nearly an equivalent number of landowners who draw water from fish-bearing streams in the headwaters have voluntarily installed water storage and limited their dry-season pumping. Over the next 10 years the goal is to enroll at least 70 additional landowners in the program, which will significantly reduce dry season pumping by developing storage for all dry season human water use. Additional projects needed to reduce dry season pumping include water storage for institutions, the creation of off-stream ponds for fire and agricultural use, and the development of emergency water supplies.

b. Groundwater Recharge, Large Wood Structures for Streamflow Enhancement, and Wetland Enhancement

i. Limiting Factors Addressed

This program, while focused primarily on increasing summer streamflow, will address all factors related to summer rearing, as described in section IV.B.1.a.i, above. Additionally, projects within anadromous stream reaches will improve winter rearing conditions by increasing floodplain connectivity, access to and the extent of flow refuge, and instream habitat complexity.

ii. Description of Action

As noted above, streamflow and groundwater monitoring in the Mattole headwaters indicates that human water use is a significant factor exacerbating low summertime streamflows, but is not the only or even primary underlying cause of low flows in most stream reaches. Reducing or eliminating surface water withdrawals in the summertime will keep the existing water instream, but will not ensure sufficient flow in critical summer rearing reaches, especially during drought years. Groundwater analysis performed by BLM engineer Brad Job shows that Mattole groundwater moves very quickly through the soil and that any groundwater recharge projects will need to be designed to either slow groundwater flow or utilize a design whereby groundwater is continuously charged by adjacent surface water.

Predictions of altered precipitation patterns with climate change also point to an increased need for groundwater recharge projects. At the 2009 American Fisheries Society conference in Nashville, TN, several speakers (including Jack Williams of Trout Unlimited and Tim Beechie of NOAA Fisheries) discussed the importance of prioritizing restoration projects that will increase resilience of watersheds and endangered species to climate change. Both speakers discussed the need to improve stormwater infiltration, reconnect rivers and floodplains, and restore incised channels through meadow restoration and riparian and wetland restoration. Because both summer drought and winter flooding are predicted to increase, restoration projects that decrease winter runoff and flooding and increase summer streamflows are the highest priority (Bisson 2008).

For these reasons, the MRRP has embarked on a Groundwater Recharge, Large Wood Structures for Streamflow Enhancement, and Wetland Enhancement Program. This program will enhance summer streamflows and provide improved winter rearing habitat. Currently the first phase of the program is focused on planning, coordination, and outreach with scientists and agency personnel, determining the most effective design, creating project designs and pilot projects, and obtaining program funds. Project designs currently under consideration include off-channel ponds and wetlands, infiltration swales and infiltration basins, channel-spanning large wood structures, and beaver-dam inspired structures. Project design has been significantly inspired by beaver ponds, as they have demonstrated to have high value as habitat for coho rearing (Pollock et al. 2004, Nickelson et al 1992) and potential for groundwater recharge. Numerous local and regional scientists, including Michael Pollock from NOAA's Northwest Fisheries Science Center, are providing technical guidance for all stages of the project.

The second phase of the program, which begins in 2011, is to obtain funding and permits to implement the pilot projects, conduct pre- and post-project monitoring on the pilot projects, prepare a plan for further implementation of groundwater recharge on all 13 headwaters tributaries, and to disseminate information from pilot projects to agencies and river restoration groups throughout the Pacific Northwest. The third phase of the program includes implementing additional groundwater recharge projects (approximately 400-700) from 2012-2020, with implementation of the top 40 projects in Lost River, Baker Creek, McKee Creek, and Thompson Creek occurring within the first three years. Throughout this period, project monitoring and adaptive management will occur in order to implement all projects in an effective manner by 2020. If all projects are implemented, and water storage and forbearance projects completed for the 70 remaining households and all headwaters institutional users, we predict that September flows (the minimum low-flow period) in the upper mainstem will remain at or above the 1 cfs necessary to provide contiguous instream habitat for coho salmon.

c. Recovery Rearing

i. Limiting Factors Addressed

The Mattole Recovery Rearing Program will address coho mortality due to poor summer and winter rearing conditions, and outmigrants entering the ocean at a suboptimal size for survival.

ii. Description of Action

Since 1999, the MSG has been working to rescue coho salmon from inhospitable conditions due to low instream flows in the Mattole headwaters. Due to disagreements from agency personnel on whether or not this action was warranted, permission to rescue coho salmon was denied in recent years. In 2010, due to the emergency state of the population, the MSG again requested permission to rescue coho salmon from inhospitable conditions, but with the added caveat that juveniles be reared in artificial conditions due to the extreme low numbers of individuals and the current lack of suitable habitat in the watershed.

The current product of this most recent request is the collaboration of the MSG with NOAA Fisheries, BLM, CDFG, and USFWS to develop the Mattole Recovery Rearing Program. The program works to rescue coho salmon fry and juveniles from the mainstem and tributaries above RM 47.0 and rear them in a facility containing artificial ponds, currently located on South Fork Bear Creek. Juveniles will be raised and released in either the fall or the following spring to avoid stressful instream conditions. The program will rear up to a maximum of 7,500 juvenile coho salmon.

The purpose of the program is to immediately avoid extirpation of the Mattole coho population and aid in the recovery of the SONCC coho salmon ESU. This will be accomplished by increasing survival of coho salmon during their freshwater life stage and enhancing survival during ocean migration, due to increased size of outmigrant smolts upon ocean entry. The project will be implemented until an adult coho population estimate of more than 250 individuals is maintained for at least one generation period and mainstem and tributary reaches above river mile (RM) 47 no longer become disconnected during the summer for this same period.

Currently, Technical and Steering Committees have been formed with MSG staff and personnel from the agencies listed above, and the program has been deemed necessary by all those involved. The MSG, in coordination with the committees, is currently finalizing the proposed action of the program with a Rescue Rearing Management Plan and 5-Year Plan, applying for permits, and obtaining funding for the program. The program is planned to begin in 2011, depending on permitting and funding timeframes.

d. Instream Habitat Enhancement

i. Limiting Factors Addressed

Instream habitat enhancement is primarily targeted as a Tier 1 strategy to improve winter rearing conditions by creating and providing access to backwaters, floodplains, and slow-water habitat during high flows. However, projects are also focused on summer rearing habitat and all projects implemented within the Mattole Instream Habitat Enhancement Program will have positive benefits for all freshwater life stages.

ii. Description of Action

As mentioned in previous sections, timber harvest, stream cleaning, and floodplain clearance have greatly reduced the abundance of instream woody material in much of the Mattole River Watershed, drastically decreasing the quality and complexity of instream habitat. This reduction in instream large wood (and in a few cases floodplain development or bank stabilization) has also reduced the incidence of side-channel, slackwater, and alcove habitat, and has implications for nutrient retention and sediment dynamics.

The MSG has been working to enhance instream habitat since 1985 and has added over 280 large wood structures to the watershed, most of these within the headwaters. These projects have predominantly been focused on improving summer rearing habitat, although many of the projects have incidentally benefited all life stages of coho salmon.

Future projects will primarily focus on improving winter rearing habitat, while also improving summer rearing conditions. These projects are intended to increase the availability of high flow refuge for coho fry and juveniles, and will also provide more available rearing habitat by increasing pool volume and occurrence, and more suitable conditions conducive to feeding and growth. Projects will generally consist of placement of instream large wood, augmentation of side-channel/alcove/slough habitat, and construction of channel-spanning large wood groundwater-recharge impoundment structures. Current and future projects are focused on the headwaters and estuary, although projects are planned throughout the watershed to increase habitat connectivity.

e. Properly Screening Water Diversions

i. Limiting Factors Addressed

Properly screening water diversions in the Mattole will avoid direct mortality of juveniles through impingement and entrainment.

ii. Description of Action

Evidence suggests that while nearly all instream diversions in the Mattole have a wire or mesh screen on the intake, few of the screens are adequate to prevent impingement and death of juvenile salmonids (McKee 2004b, CDFG 2004). Increased awareness of the importance of properly screened diversions is needed. Projects will include working with landowners on the necessity of a properly screened diversion, ensuring availability of adequate screens, and replacing existing inadequate screens. Sanctuary Forest has worked with local fabricators to produce a screen that meets CDFG and NOAA design criteria. This screen is now available at the Sanctuary Forest office in Whitethorn. Currently, very few landowners outside of SFI's Tank and Forbearance Program have screens that meet CDFG and NOAA criteria.

2. Tier 2 Strategies: Necessary to Increase Population Abundance and Distribution

a. Reduce Sediment Inputs

i. Limiting Factors Addressed

The Mattole Restoration Council's (MRC) Good Roads, Clear Creeks (GRCC) program will address winter rearing limitations due to chronic turbidity, simplification of instream habitat, and impacts to aquatic ecosystems due to excessive fine sediment.

ii. Description of Action

Reducing sediment inputs to the watershed – especially fine sediment – will improve spawning and rearing habitat. The GRCC program has been systematically treating sediment sources in the watershed since 2001, beginning in the headwaters and working downstream. Prior to the program's inception, other watershed groups, public agencies, and private landowners implemented sediment reduction projects throughout the watershed. Projects include road upgrades, culvert replacements, road decommissioning, and bank and landslide stabilization. When possible, bank and landslide stabilization projects incorporate woody material to enhance fish habitat.

Sediment sources have now been treated in over 60% of the watershed, including in nearly all of areas with recent documented coho presence (MRRP 2009c). In the past decade, more than an estimated 550,000 cubic yards of sediment have been stabilized.

Sources still need to be treated, however, in areas where either coho were found historically or more recently. Excessive sedimentation is also currently affecting mainstem and estuarine habitat. Sediment-source inventories in the Upper North Fork Mattole, Honeydew Creek, and the Petrolia area have identified sites with over 1 million additional cubic yards of potential sediment delivery. With available funding, these sites will be treated over the next 3-5 years. Future sediment-source inventories will focus on Squaw Creek and the Lower North Fork Mattole – the only large portions of the watershed where sediment sources have not been inventoried and treated in the past decade.

b. Riparian Ecosystem Restoration

i. Limiting Factors Addressed

In the near-term, excessive summertime water temperatures due to a lack of riparian canopy will be addressed. In the long term, all issues relating to a lack of complex instream habitat will be addressed.

ii. Description of Action

The MRC's Riparian Ecosystem Restoration (RER) program uses successional revegetation, bioengineering, and riparian silviculture to address poor riparian conditions and near-stream sediment sources.

Over the past decade over 200,000 trees, mostly redwood (*Sequoia sempervirens*) and Douglas-fir (*Pseudotsuga menziesii*), have been planted in riparian areas, most of which are upstream of Honeydew. In much of the watershed, riparian areas that were cleared in the past century are re-growing vigorously thanks to natural regeneration and restoration approaches. Accordingly, the RER program is currently focused on reaches where the natural re-establishment of riparian vegetation has been delayed due to inhospitable site conditions, and on reducing streamside sediment sources (working in concert with the GRCC program), which can be particularly important sources of chronic turbidity. Most of these stream reaches are in the lower half of the watershed (downstream from Grindstone Creek), and most are not currently known to support coho salmon. However, the re-establishment of a mature riparian forest along low-gradient, larger streams will be important in regaining high-quality winter rearing (non-natal) habitat.

c. Land Acquisition/Conservation Easements

i. Limiting Factors Addressed

Land Acquisition and Conservation Easements will help to address all limiting factors for all stages of the freshwater life cycle.

ii. Description of Action

Sanctuary Forest's Conservation Lands Program works with private landowners and public agencies to ensure long-term conservation management of land in the Mattole through conservation easements, cooperative management agreements, and land acquisition. Currently, the program conserves approximately 3,300 acres within the watershed through a combination of conservation easements and fee-owned properties. Additional conserved lands include the Upper Mattole River and Forest Cooperative (UMRFC), a collaborative entity of public, private, state, Federal, and non-profit organizations working together to manage over 5,700 acres of the Mattole for conservation values. Landowners in other areas of the watershed also have placed conservation easements on their properties that are held by the North Coast Regional Land Trust.

Increased residential development – particularly development without restrictions on water diversion – would further impact the remaining coho habitat in the watershed by increasing the duration and geographical distribution of low flows. SFI's established conservation acquisition program, in combination with easements held by other land trusts and other innovative strategies for managing private land for conservation values, can continue to be used as a tool to protect the highest quality habitat and additional habitat needed for recovery of the population.

SFI is currently developing a Conceptual Area Protection Plan for the Mattole headwaters, which will use data on streamflows, groundwater, and existing and potential water diversions, combined with other key conservation factors, to prioritize conservation efforts. Sanctuary Forest is also working on a high-priority collaborative project to conserve 570 acres in the Lost River drainage. This property has high potential for successful streamflow enhancement projects. It is located immediately upstream of 1.2 miles of stream that has high-potential to serve as prime coho habitat with the restoration of adequate flow. This same property is also located 0.5 miles of the mainstem Mattole where significant numbers of juvenile salmonids have perished in drying pools in the last decade.

d. Forest Management

i. Limiting Factors Addressed

Forest Management will address all factors associated with low summertime streamflows. This strategy could also have positive long-term impacts on winter rearing habitat quality by increasing the potential for instream wood recruitment.

ii. Description of Action

Forest management is important to the long-term recovery and health of the watershed and its coho populations. Overstocked young forests in the Mattole headwaters appear to be a significant factor compounding the low flow problem. High evapotranspiration rates during the summer are as significant in their impacts on low flows as human water withdrawals. Additionally many of these second-growth forests pose a severe fire-hazard. A forest thinning and management program will be further developed, incorporating streamflow enhancement goals and forest ecosystem health goals.

e. Groundwater Infiltration Restoration

i. Limiting Factors Addressed

This strategy will address all factors relating to low summer streamflow. It will also contribute to the attenuation of winter high flows, although possibly not to a quantifiable extent.

ii. Description of Action

Groundwater infiltration restoration will reduce runoff from roads and other impermeable or compacted surfaces and increase groundwater infiltration and storage.

While sediment sources have been treated in over 60% of the watershed, few of those projects included groundwater infiltration features needed to restore hill-slope hydrology. Most mid- and lower-slope roads intercept and “daylight” groundwater, causing it to run off as surface water.

A groundwater infiltration restoration program will be developed and implemented to reduce runoff on existing roads and will be incorporated into the design of new roads. The program will also address run-off from impermeable surfaces created by residences, institutions, and agriculture.

f. Education and Watershed Stewardship

i. Limiting Factors Addressed

Education and Watershed Stewardship will help to address all limiting factors for all life stages of the freshwater life cycle.

ii. Description of Action

Educational efforts by MRRP groups are ongoing. Education and watershed stewardship is imperative to ensuring landowners and the community understand the coho life cycle, life history strategy, and habitat requirements, as well as how their actions impact coho and what they can do to minimize their effects.

C. Prioritization by Tributary/Stream Reach

Streams/reaches are presented by priority ranking from 1 to 4 in Figure 36 and following tables, with the applicable Tier 1 and Tier 2 strategies noted for each stream/reach. Streams/reaches were placed in each priority category based on current or recent confirmed coho presence, use by multiple life stages or life stages for which habitat seems to be in short supply, current habitat quality, projected habitat response, and the feasibility of project implementation. The criteria used in defining each priority category are noted at the beginning of the sub-section for the respective category. In some of these streams, only a short section of the entire stream offers potential habitat for coho (e.g., instream habitat enhancement activities will only occur in stream reaches with a suitable gradient for coho use).

The implementation of Tier 1 strategies in Priority 1 streams are the projects which are the most important to reverse the decline of coho in the Mattole. However, lower-tier strategies in lower priority stream reaches may be pursued before completing all applicable Tier 1 strategies in Priority 1 streams. It is expected that our evolving knowledge of coho habitat use throughout the watershed, over the entire coho life cycle may change our view of priority habitats over time. Note that Recovery Rearing, Properly Screening Water Diversions, and Education and Watershed Stewardship are not included below as they are not restricted to specific stream reaches.

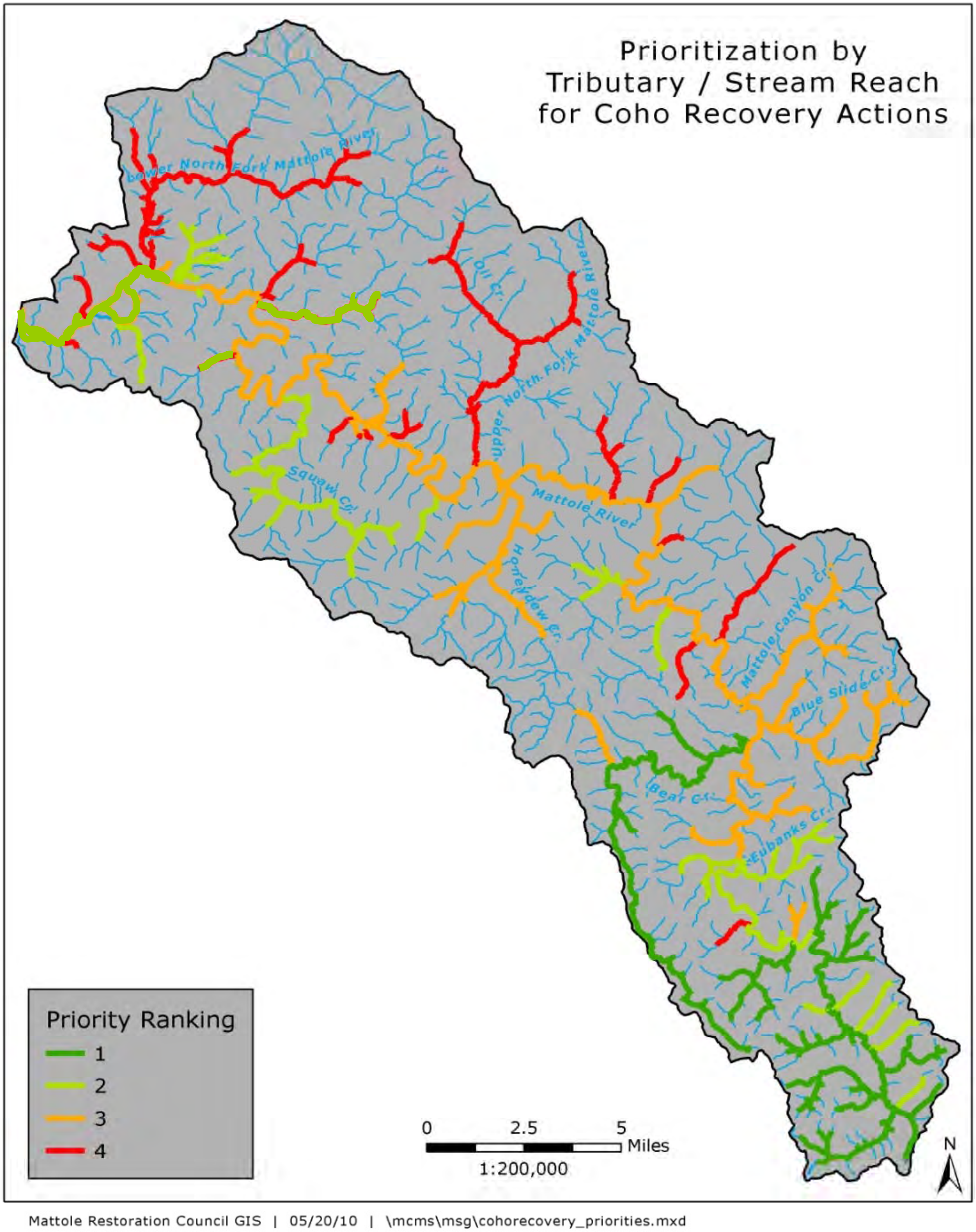


Figure 36. Streams and stream reaches targeted for Coho Recovery Actions, color-coded by priority ranking.

1. Priority I Tributaries/Mainstem Reaches

In Priority I tributaries and mainstem reaches, coho salmon rearing *and* spawning has been documented in the last 10 years. Instream habitat conditions are generally favorable, especially in regards to temperature and a lack of excessive sediment sources. These are primarily low-gradient streams located in the upper third of the watershed. Implementing Tier 1 strategies in Priority 1 tributaries is considered to be necessary to avoid extirpation of coho salmon in the Mattole River Watershed.

Table 16. Priority I tributaries and mainstem reaches and applicable recovery strategies.

Approx. River Mile	Tributary/Reach Name	Tier 1			Tier 2		
		Instream Habitat Enhancement	Water Storage Tanks & Forbearance	Wetland Enhancement & Groundwater Recharge	Riparian Ecosystem Restoration	Sediment Reduction	Land Acquisition/ Conservation Easements
60.8	Ancestor	P		X	C	C	C/X
57.6	Baker	X		X		C	C/X
52.1	Bridge	P	X	X	P	C	C/X
58.8	Lost River	X		P	C	C	C/P
>56.5	Mainstem, above Whitethorn	C/P	I	P	C	C	C/X
52.1-56.5	Mainstem, from Bridge Creek upstream to Whitethorn	C/P	I			C	C/X
52.8	McKee	X	X	X	C	C	X
60.8 +0.15	McNasty (trib. to Ancestor)		X	X		C	C/X
58.4+2.2	N. Fork Thompson (Danny's)					C	X
42.8+6.0	South Fork Bear	C/X	X		C	C	C/X
58.4	Thompson	C/P	P	P	C	C	C/X
42.8	Bear (excluding N. & S. forks)	C/X				C	
56.2	Upper Mill	C/P	X	X		C	C/X
54.0	Van Arken	X		X	C	C	X
58.4+0.15	Yew (trib. to Thompson)	X		X	C	C	C
Explanation of codes:		**X** = Strategy considered necessary in stream/reach **P** = Projects in planning phase **I** = Projects currently in implementation phase **C** = Projects completed in stream/reach					

2. Priority II Tributaries/Mainstem Reaches

Priority II streams include tributaries and stream reaches where coho juveniles, but no adults, have been observed within the past 10 years or evidence of a strong historical population exists. Tributaries are generally in intermediate stages of recovery, with habitat that does not appear to be presently suitable for self-sustaining coho populations. Additional criteria include few or recently-treated chronic sediment sources, recovering riparian area, and suitable or nearly suitable temperatures. In many of these streams a few juveniles are observed in most years. Many of these reaches may be most important in serving as winter habitat for displaced juveniles. Priority II tributaries and reaches and strategies are necessary in order to avoid further significant decline of coho salmon in the Mattole.

Table 17. Priority II tributaries and mainstem reaches and applicable recovery strategies.

Approx. River Mile	Tributary/Reach Name	Tier 1			Tier 2		
		Instream Habitat Enhancement	Water Storage Tanks & Forbearance	Wetland Enhancement & Groundwater Recharge	Riparian Ecosystem Restoration	Sediment Reduction	Land Acquisition/ Conservation Easements
55.6	Anderson		C	X		C	C/X
47.4	Big Finley	X			C	C	C/X
6.1	Clear	X				C	
5.4	East Mill	C/X	X	X	C	I	
47.7	Eubanks	X	X	X	C	C	C/X
34.6	Fourmile	X			C	C	C/X
56.8	Gibson	X	X	X	X	C	C/X
56.5	Harris	X	X	X	X	C	X
58.7	Helen Barnum	X		X		C	C/X
11.7	Indian	X				C	
1.0	Lower/Little Bear	P	X	P	P	I	
2.8	Lower Mill	C				C	C/X
8.0	McGinnis	X		X	P	X	
42.8+5.0	N. Fork Bear				X	C	X
55.8	Ravasoni (East Anderson)		X	X	X	C	X
14.9	Squaw	X			P	X	C/X
57.1	Stanley	X	X	X	X	C	X
24.1	Woods	X			P	X	X
0-5.4	Mattole Estuary and lower mainstem (downstream of Petrolia)	C/P		X	I	I	C/X
Explanation of codes:		**X** = Strategy considered necessary in stream/reach **P** = Projects in planning phase **I** = Projects currently in implementation phase **C** = Projects completed in stream/reach					

3. Priority III Tributaries/Mainstem Reaches

Priority III tributaries and mainstem reaches have had either very few or no coho juvenile sightings in the past 20 years and are either naturally less suitable as coho habitat than higher priority streams, or their ability to provide coho habitat has been significantly impaired through past land use. Recovery of suitable habitat conditions in these tributaries may take decades, even with intensive restoration activities.

Table 18. Priority III tributaries and mainstem reaches and applicable recovery strategies.

Approx. River Mile	Tributary/Reach Name	Tier 1			Tier 2		
		Instream Habitat Enhancement	Water Storage Tanks & Forbearance	Wetland Enhancement & Groundwater Recharge	Riparian Ecosystem Restoration	Sediment Reduction	Land Acquisition/ Conservation Easements
42.0	Blue Slide	X	X	X	I	C	
45.9	Deer Lick	X	X	X	C	C	
39.0	Grindstone	X			C	C	C/X
26.5	Honeydew	C/X			P	P	X
46.8	Little Finley				C	C	X
41.1	Mattole Canyon	C/X	X	X	C	C	C/X
19.2	Pritchett	?			X	X	
36.6	Sholes	X			C	C	C/X
31.7	Westlund	?			C	C	C/X
44.0	Wolf/Box Canyon	X			C	C	
5.4-52.1	Mattole Mainstem, Petrolia area upstream to Bridge Creek	X			X	X/P	
Explanation of codes:		**X** = Strategy considered necessary in stream/reach **P** = Projects in planning phase **I** = Projects currently in implementation phase **C** = Projects completed in stream/reach **?** = Lacking information on conditions in stream					

4. Priority IV Tributaries

Priority IV streams have no contemporary record of coho use, and are either heavily impacted by past land use, or naturally contain very marginal coho habitat. It is much harder to identify specific restoration projects in these drainages, as a more comprehensive restoration effort is likely to be necessary, and recovery of suitable coho habitat, if possible, will take decades. However, the mouths and lower reaches of some of these streams may offer occasional winter habitat for non-natal juveniles, and may have historically served this important role.

Table 19. Priority IV tributaries and applicable recovery strategies.

Approx. River Mile	Tributary Name	Tier 1			Tier 2		
		Instream Habitat Enhancement	**Water Storage Tanks & Forbearance**	**Wetland Enhancement & Groundwater Recharge**	**Riparian Ecosystem Restoration**	**Sediment Reduction**	**Land Acquisition/ Conservation Easements**
7.8	Conklin	X			P	I	
30.4	Dry	?			X	X	C/X
32.8	Gilham				P	C	C/X
19.2	Granny				I	X	C/X
1.8	Jim Goff				X	X	
4.7	Lower North Fork Mattole	?			X	X	
31.3	Middle	?			C	C	C/X
50.2	Nooning					C	X
19.9	Saunders	X			P	X	C/X
1.3	Stansberry					I	
25.5	Upper North Fork Mattole	X			I	P	
Explanation of codes:		**X** = Strategy considered necessary in stream/reach **P** = Projects in planning phase **I** = Projects currently in implementation phase **C** = Projects completed in stream/reach **?** = Lacking information on conditions in stream					

D. Streamlined, Expedited Funding and Permitting Process

Data document emergency needs in regards to restoration and recovery efforts for coho salmon in the Mattole River Watershed and in the state of California. Unfortunately, current timelines and restrictions for funding and permits do not necessarily reflect this emergency state, or take into consideration the current economic climate. In this regard, the MCRS recommends the following:

- Design and implement an expedited permitting process for all restoration activities, much like that designed around CDFG's Fisheries Restoration Grants Program. It is our understanding that NOAA Fisheries currently is working on a similar streamlined process, and we encourage the completion of this document as soon as possible.
- Focus funding efforts based on NOAA Fisheries designation of Core Populations and priority actions based on state and Federal recovery plans, as well as the MCRS.
- Designate congressional funding for recovery in California, based on the above.
- Designate congressional funding for recovery monitoring in California.
- Ensure state and Federal policy decisions are in place regarding direct enhancement, so programs can move forward quickly based on top policy decisions.
- Revise funding sources and requirements to focus on current main limiting factors to California salmonids.
- Remove or decrease cost-share requirements, especially non-Federal cost-share components.

V. Monitoring Recovery

A. Monitoring Viability

Currently, there is no ESU- or state-wide plan for monitoring viability of coho populations. CDFG has been working on a Coastal Monitoring Plan since 2002, but has yet to complete a final plan. NOAA Fisheries *CCC Coho Salmon ESU Draft Recovery Plan* (NMFS 2010) and *Salmon, Steelhead and Trout in California: Status of Emblematic Fauna* (Moyle et al. 2008) both state that an important step in the recovery of California salmonids is to complete the Coastal Monitoring Plan. In addition, NOAA Fisheries states that a priority recovery action needed for SONCC coho salmon is to complete and fund a population monitoring plan (http://swr.nmfs.noaa.gov/recovery/Coho_SONCC.htm).

Because no monitoring plan exists for California, the MSG produced the *Salmonid Population Monitoring Plan* (Plan) in 2009 (MSG 2009). The overarching goal of the Plan is to frame the collection of salmonid and habitat data based on the Viable Salmonid Population (VSP) concept in McElhany et al. (2000) and the Willamette/Lower Columbia Technical Recovery Team’s (TRT) *Interim Report on Viability Criteria for Willamette and Lower Columbia Basin Pacific Salmonids* (McElhany et al. 2003). Only through long-term monitoring of the parameters that are used to assess salmonid population viability will the MSG and state and Federal agencies be able to determine where on the road to salmon recovery we currently reside, and what actions need to be taken to ensure that Mattole River salmon populations survive in perpetuity. MSG envisions that similar monitoring protocols will be used throughout the state of California, if not across the entire west coast, in order to exchange data and better understand the current and future abundance and risks of the west coast ESUs.

The VSP concept in McElhany et al. (2000) uses *four* parameters to evaluate a population’s viable status: (1) abundance, (2) population growth rate, (3) population spatial structure, and (4) diversity. The TRT (McElhany et al. 2003) uses this VSP concept, along with NOAA Fisheries’ listing criteria, identification of independent populations, and an assessment of the persistence probability of individual populations to outline viability criteria for the Willamette and Lower Columbia Basin ESUs. The TRT (McElhany et al. 2003) outlines *five* attributes that must be assessed in order to determine a population’s persistence: (1) adult abundance and productivity, (2) juvenile outmigrant population growth rate, (3) within-population diversity, (4) within-population spatial structure, and (5) habitat utilization. MSG’s Plan utilizes the five TRT attributes to frame salmonid monitoring, as these can then be condensed into the four McElhany et al. (2000) parameters, as needed.

The objectives and associated research questions of the *Salmonid Population Monitoring Plan* are to determine the following for each salmonid species, and in this context, for coho salmon:

(1) Determine adult abundance and productivity
   a. Abundance: What are the yearly escapement and spawning estimates?
   b. Productivity: What is the slope of the long-term time series of adult abundance?

(2) Determine juvenile abundance
   a. What are the yearly estimates of juvenile abundance?
   b. What is the slope of the long-term time series of juvenile abundance?

(3) Describe population diversity
   a. What are the various life history strategies of each species?
   b. What is the suite of genetic expressions in the adult populations?

(4) Describe population spatial structure
    a. What is the adult population spawning distribution throughout the basin?
    b. What is the juvenile population distribution throughout the basin?
(5) Determine habitat utilization
    a. What is the spatial structure of habitat in the basin?
    b. What habitats are being utilized by the various life stages of each species?

The following list prioritizes monitoring activities into three tiers of priority, with the first tier signifying the highest priority:

(1) Downstream migrant trapping, spawner surveys, summer steelhead dives, DIDSON™ Sonar Technology or adult weir, estuary monitoring, and headwaters monitoring
(2) Juvenile presence/absence surveys, Life Cycle Monitoring Tributaries (i.e. DSMT and adult escapement estimates), rapid stream surveys, temperature and flow monitoring
(3) Genetic analyses, and otolith preparation and analyses

MSG's Plan is in line with the Monitoring Chapter of NOAA Fisheries *CCC Coho Salmon ESU Draft Recovery Plan* (NMFS 2010). Ensuring that data are collected in an integrated manner and at the appropriate scale will facilitate assessment of population trends and persistence, provide direct input to restoration and enhancement projects, and illuminate unmet monitoring needs.

B. Addressing Data Gaps

As mentioned in *Mattole Limiting Factors* (section III), there are many questions that need to be addressed and modifications to existing monitoring programs need to be made. The following is a list of additional information (in no particular order) that is needed in order to accurately reflect abundance, distribution, survival rates, and the main factors limiting survival of coho salmon in the Mattole River Watershed.

1. Determine exact adult escapement estimate

Exact adult escapement estimates are difficult in a river system the size of the Mattole. However, a DIDSON™ acoustic sonar unit used low in the system appears to be the best opportunity for obtaining an estimate. This option will be rigorously be pursued if results and experiences with pilot projects currently underway elsewhere in Northern California prove to be favorable.

2. Determine total distribution of redds

In addition to known spawner sites, access to creeks where juveniles are present (in order to determine spawner probability and density) is needed.

3. Determine extent of fry and juvenile winter migration and use of the mainstem, lower river tributaries, and estuary

Fall and winter snorkel surveys, as well as outmigrant trapping, will help determine winter migration, distribution, and habitat use.

4. **Determine presence-absence of juveniles throughout the watershed**

Monitoring lower and upper reaches in tributaries throughout the watershed will improve our assessments of distribution. In addition, outmigrant trapping or minnow trapping should occur at all tributaries where presence is suspected but not confirmed.

5. **Determine juvenile outmigrant population estimate**

Determining a population estimate includes identifying how many juveniles are migrating prior to late April and conducting trap efficiencies. Juvenile population estimates are difficult due to the low numbers of coho caught in the lower trap. However, mark-recapture should occur at least once through the season to assess trap efficiency. In addition, the validity of using other population estimates (e.g. basing efficiency on Chinook recapture, or potential estimates based on timing frequency) should be checked. Running traps upriver when flows are too high to put in a trap in the lower river may be useful. In addition, a larger screw trap may be able to handle larger flows, and therefore be installed in the river at an earlier date to capture a larger percentage of the outmigrants.

6. **Determine winter and summer juvenile mortality rates, and primary mechanisms of mortality**

Further information is needed to determine how flow refuge and low summer flow influence summer and winter survival rates. Specific information is needed regarding the percentage of the population that perishes from low flows and dry reaches. In addition, we need to know how winter survival rates correlate to high flows, amount of flow refuge, and restoration projects.

7. **Determine extent of low flows**

Low flows have been monitored every dry season at five sites in the Mattole headwaters mainstem beginning in 2004 and in 15 fish-bearing tributaries since 2006. Additional monitoring is needed to determine the extent of low flows and dry reaches in each tributary and in the mainstem between the established monitoring sites.

8. **Determine extent of low flow issue related to human use, aggradation, and recharge**

Continued assessments aimed to determine the major causes of low flows are need so that appropriate restoration activities can be implemented.

9. **Assess large wood needs in priority streams**

Assessment of large wood amounts, deficiencies, and potential recruitment for winter and summer rearing habitat in priority streams should continue.

10. Increase monitoring of project effectiveness and incorporate results in adaptive management

Monitoring of project effectiveness is essential to understanding fish response to changing habitat conditions and if projects are having the desired effect.

11. Inventory major sediment sources in priority streams

Continue sediment inventories in priority streams, especially the Squaw Creek drainage.

C. Measuring Success

Success will be measured on many scales. At the current level of crisis, avoiding extirpation of coho salmon from the Mattole River Watershed will be deemed a success. However, the successive desired result is to observe increasing populations for every cohort. Recovery success will ultimately be achieved when 6,500 spawners return to the Mattole. This is the required number determined for the Mattole by Williams et al. (2008) that will contribute to satisfying the 50% low-risk populations requirement for the Southern Coastal Basins diversity stratum of the SONCC ESU, thus enabling the ESU to become viable.

Implementation of the MCRS as outlined will also be seen as a success. This entails following the priority rankings, implementing projects, monitoring for recovery, addressing data gaps, and adapting our strategies as new information becomes available. Effectiveness monitoring – including habitat, fish use, and survival rate monitoring – is essential for all projects to ensure that projects were implemented as planned, and that they are producing the desired effect.

VI. References

Aquatic and Riparian Effectiveness Monitoring Program (AREMP). 2005. Watershed monitoring for the Northwest Forest Plan: Data summary 2005, Franciscan Province. USDA Forest Service, Pacific Northwest Regional Office, and Bureau of Land Management, Oregon State Office. Corvallis, OR.

Arthaud, D.L., C.M. Green, K. Guilbault, and J.V. Marro. 2010. Contrasting life-cycle impacts of stream flow on two Chinook salmon populations. Hydrobiologia 655 (1): 171-188.

Baier, A. 2008. Summary report of water temperature and juvenile salmonid presence/absence monitoring, May-October 2008, Mattole River watershed. Final report prepared for Bureau of Land Management, Arcata field office. Mattole Salmon Group, Petrolia, CA. 61 pp.

Barrowman, N.J., R.A. Myers, R. Hilborn, D.G. Kehler, and C.A. Field. 2003. The variability among populations of coho salmon in the maximum reproductive rate and depensation. Ecological Applications, 13(3): 784 –793. (www.fmap.ca/ramweb/paperstotal/Barrowman_etal_2003.pdf)

Beamish, R.J., D.J. Noakes, G.A. McFarlane, W. Pinnix, R. Sweeting, and J. King. 2000. Trends in coho marine survival in relation to the regime concept. Fisheries Oceanography 9(1): 114–119.

Beechie, T.J., E. Beamer, and L. Wasserman. 1994. Estimating coho salmon rearing habitat and smolt production losses in a large river basin, and implications for habitat restoration. North American Journal of Fisheries Management 14:797-811.

Beechie T.J., and T.H. Sibley. 1997. Relationship between channel characteristics, woody debris, and fish habitat in northwestern Washington streams. Transactions of the American Fisheries Society 126: 217–229.

Beesley, S. and R. Fiori. 2007. Klamath River tributary delta and subsurface flow study, lower Klamath River sub-basin, California. Final technical report for Yurok Tribal Fisheries program, Klamath, CA. 104 pp.

Bell, E. and W.G. Duffy. 2007. Previously undocumented two-year freshwater residency of juvenile coho salmon in Prairie Creek, California. Transactions of the American Fisheries Society 136: 966–970.

Bell, E., W.G. Duffy, and T.D. Roelofs. 2001. Fidelity and survival of juvenile coho salmon in response to a flood. Transactions of the American Fisheries Society 130: 450–458.

Bellman, M.A., E. Heery, and J. Majewski. 2010. Observed and estimated total by-catch of salmon in the 2008 U.S. west coast groundfish fisheries. West Coast Groundfish Observer Program. Northwest Fisheries Science Center, Seattle, WA.

Bilby, R.E., and P.A. Bisson. 1998. Function and distribution of large woody debris. Pages 324-346 in R. J. Naiman and R. E. Bilby, editors. River ecology and management: lessons from the Pacific coastal ecoregion. Springer-Verlag, New York, N.Y., USA.

Bilby. R.E. and J.W. Ward. 1989. Changes in characteristics and function of woody debris with increasing size of streams in Western Washington. Transactions of the American Fisheries Society 118:368-378.

Bisson, P.A. 2008. Salmon and trout in the Pacific Northwest and climate change. U.S. Department of Agriculture, Forest Service, Climate Change Resource Center, June 16, 2008. http://www.fs.fed.us/ccrc/topics/salmon-trout.shtml

Bjorkstedt, E.P., B.C. Spence, J.C. Garza, D.G. Hankin, D. Fuller, W.E. Jones, J.J. Smith, and R. Macedo. 2005. An analysis of historical population structure for evolutionarily significant units of chinook salmon, coho salmon, and steelhead in the north-central California coast recovery domain. National Marine Fisheries Service, Southwest Fisheries Science Center. Santa Cruz, CA. 231 pp.

Bjornn, T.C., and D.W. Reiser. 1991. Habitat requirements of salmonids in streams. In: Meehan, W.R. Influences of forest and rangeland management of salmonid fishes and their habitats. Bethesda, MD: American Fisheries Society: 83-138.

Bolliet,V.A., Bardonnet, M. Jarry, J.C. Vignes, and P. Gaudin. 2005. Does embeddedness affect growth performance in juvenile salmonids? An experimental study in brown trout, *Salmo trutta*. Ecology of Freshwater Fish 14(3): 289–295.

Bradford, M. 1995. Comparative review of Pacific salmon survival rates. Canadian Journal of Fisheries and Aquatic Sciences 52(6): 1327–1338.

Brakensiek, K.E. 2002. Abundance and survival rates of juvenile coho salmon (*Oncorhynchus kisutch*) in Prairie Creek, Redwood National Park. A Thesis Presented to The Faculty of Humboldt State University, January, 2002.

Brakensiek, K.E., and D.G. Hankin. 2006. Estimating overwinter survival of juvenile coho salmon in a Northern California stream: accounting for effects of passive integrated transponder tagging mortality and size-dependent survival. Transactions of the American Fisheries Society 135: 1681-1697.

Brookshire, E.N.J. and K.A. Dwire, 2003. Controls on patterns of coarse organic particle retention in headwater streams. Journal of the North American Benthological Society 22:17-34.

Brown, L.R. and P.B. Moyle. 1991. Status of coho salmon in California. Report to the National Marine Fisheries Service. Davis, CA. 89 pp.

California Department of Fish and Game (CDFG) 2002. Status review of California coho salmon north of San Francisco. Report to California Fish and Game Commission, April 2002. 232 p.

California Department of Fish and Game (CDFG) 2004. Recovery strategy for California coho salmon. Report to the California Fish and Game Commission. California Department of Fish and Game, Native Anadromous Fish and Watershed Branch, Sacramento, CA. 594 pp.

Cannata, S., R. Henly, J. Erler, J. Falls, D. McGuire and J. Sunahara. 2006. Redwood Creek watershed assessment report. Coastal Watershed Planning and Assessment Program and North Coast Watershed Assessment Program. California Resources Agency and California Environmental Protection Agency, Sacramento, California.

Carlisle, S., M. Reichmuth, E. Brown, and S. C. Del Real. 2008. Long-term coho salmon and steelhead trout monitoring in coastal Marin County 2007: annual monitoring progress report. Natural Resource Technical Report NPS/SFAN/NRTR—2009/269. National Park Service, Fort Collins, Colorado.

Carlisle, S.J., and M.L. Reichmuth. 2009. Adult Escapement Monitoring Program Summary 2008-2009. Natural Resource Technical Report NPS/SFAN/NRTR. National Park Service, San Francisco Bay Area Network Inventory and Monitoring Program, Point Reyes Station, CA.

Carlson, S.R., L.G. Coggins Jr., and C.O. Swanton. 1998. A simple stratified design for mark-recapture estimation of salmon smolt abundance. Alaska Fishery Research Bulletin 5(2): 88-102.

Carter, K. 2008. Effects of Temperature, dissolved oxygen/total dissolved gas, ammonia, and pH on salmonids: implications for California's North Coast TMDLs. Appendix 4 to the final staff report for the Klamath River Total Maximum Daily Loads (TMDLs). State of California, North Coast Regional Water Quality Control Board, Santa Rosa, CA. http://www.waterboards.ca.gov/northcoast/water_issues/programs/tmdls/klamath_river/100927/staff_report/16_Appendix4_WaterQualityEffectsonSalmonids.pdf

Cederholm, C.J., R.E. Bilby, P.A. Bisson, T.W. Bumstead, B.R. Fransen, W.J. Scarlett, and J.W. Ward. 1997. Response of juvenile coho salmon and steelhead to placement of large woody debris in a coastal Washington stream. North American Journal of Fisheries Management 17: 947–963.

Chen D.G., J.R. Irvine, and A.J. Cass. 2002. Incorporating Allee effects in fish stock-recruitment models and applications for determining reference points. Canadian Journal of Fisheries and Aquatic Sciences 59:242–249.

Coastal Headwaters Association (CHA). 1982. Mattole Survey Program, first annual report, August 1981 – August 1982. Unpublished contract report, prepared for the California Dept of Fish and Game, Sacramento, CA, by Coastal Headwaters Association, Whitethorn, CA. 56 pp.

Coates, D.A., W. Hobson, B. McFadin, and C.Wilder. 2002. Mattole River watershed technical support document for the TMDLs for sediment and temperature. Draft for public review. California Regional Water Quality Control Board, North Coast Region, Santa Rosa, CA.

Dietrich, W.E. and F. Ligon. 2008. RIPPLE – A Digital Terrain-Based Model for Linking Salmon Population Dynamics to Channel Networks. Stillwater Sciences, Berkeley, CA.

Downie, S.T, C.W. Davenport, E. Dudik, F. Yee, and J. Clements. 2003. Mattole River watershed assessment Rreport. North Coast Watershed Assessment Program (NCWAP), CA Resources Agency and CA Environmental Protection Agency, Sacramento, CA. 441 pp.

Ebersole, J.L., P.J. Wigington, , J.P. Baker, M.A. Cairns, M.R. Church, B.P. Hansen, B.A. Miller, H.R. LaVigne, J.E. Compton, and S.E. Leibowitz. 2006. Juvenile coho salmon growth and survival across stream networks and seasonal habitats. Transactions of the American Fisheries Society 135:1681-1697.

Ebersole, J.L., M.E. Colvin, P.J. Wigington, S.G. Leibowitz, J.P. Baker, M.R. Church, J.E. Compton, B.A. Miller, M.A. Cairns, B.P. Hansen, and H.R. LaVigne. 2009a. Modeling stream network-scale variation in coho salmon overwinter survival and smolt size. Transactions of the American Fisheries Society 138:564-580.

Ebersole, J.L., M.E. Colvin, P.J. Wigington, S.G. Leibowitz, J.P. Baker, M.R. Church, J.E. Compton, and M.A. Cairns. 2009b. Hierarchical modeling of late-summer weight and summer abundance of juvenile coho salmon across a stream network. Transactions of the American Fisheries Society 138:1138-1156.

Ettlinger, E., M. Piovarsik, M. Rogers, and G. Andrew. 2009a. Juvenile salmonid population monitoring report, Lagunitas Creek, Marin County, California, fall 2008. Marin Municipal Water District, Corte Madera, CA, August 2009. 59 pp.

Ettlinger, E., M. Piovarsik, M. Rogers, and G. Andrew. 2009b. Lagunitas Creek salmon spawner survey report 2008-2009. Marin Municipal Water District, Corte Madera, CA, October 2009. 28 pp.

Fausch, K.D., and T.G. Northcote. 1992. Large woody debris and salmonid habitat in a small coastal British Columbia stream. Canadian Journal of Fisheries and Aquatic Sciences 49: 682-693

Fiori, R., P. Vaughn, M. Hiner, and S. Beesley. 2010. Interaction of natural hydrogeologic conditions and groundwater pumping on stranding and survival of juvenile salmonids in a Coast Range stream of Northern California. Abstract, 28th Annual Salmonid Restoration Conference, March 10-13, Redding, CA.

Francis, R.C. 1999. Ocean variability and population diversity - a match made in heaven (closing remarks). Symposium on Ocean Conditions and the Management of Columbia River Salmon. July 1, 1999. Portland, Oregon. (http://www.nwcouncil.org/library/ocean/10_variability.htm)

Gallagher, S.P. and D.W. Wright. 2008. A regional approach to monitoring salmonid abundance trends: a pilot project for the application of the California Coastal Salmonid Monitoring Plan in coastal Mendocino County Year III. California State Department of Fish and Game, Coastal Watershed Planning and Assessment Program, Fortuna, CA. 74 pp plus appendices.

Gonzales, E.J. 2006. Diet and Prey Consumption of Juvenile Coho Salmon *(Oncorynchus kisutch)* in Three Northern California Streams. M.S. Thesis, HSU. Dec. 2007. 77 pp.

Grantham, T. 2008. Data summary of Juvenile Salmonid Counts in the Upper Mattole River Basin, 2007-2008. Unpublished report prepared for Mattole Salmon Group.

Greene, C.M., and K.R. Guilbault. 2008. Density-dependent constraints during spawning and incubation. pp. 59-81 in D. Sear and P. DeVries, eds. Salmonid spawning habitat in rivers: physical controls, biological processes, and approaches to remediation. American Fisheries Society, Symposium 65, Bethesda, MD.

Harvey, B.C., and R. J. Nakamoto. 1996. Effects of steelhead density on growth of coho salmon in a small coastal California stream. Transactions of the American Fisheries Society 125:237-243.

Hayes, S.A. 2010. Importance of off-channel habitat, migration, and salmonid life history stages. From: Symposium Report – ecological opportunities for gravel pit reclamation on the Russian River, January 21, 2009, Santa Rosa. CA.

Hillemeier, D., T. Soto, S. Silloway, A. Corum, M. Kleeman, and L. Lestelle. 2009. The role of the Klamath River mainstem corridor in the life history and performance of juvenile coho salmon (Oncorhynchus kisutch). Phase 2 Report May 2007-May 2008. Prepared for Bureau of Reclamation Mid-Pacific Region, Klamath Area Office. 105 pp.

Hogan, D.L. 1987. The influence of large organic debris on channel recovery in the Queen Charlotte Islands, British Columbia, Canada. In: Erosion and Sedimentation in the Pacific Rim. IAHS Publication No. 165. International Association of Hydrological Sciences, Washington, DC. 1987. p 343-353.

Johnson, S.L., J.D. Rodgers, M.F. Solazzi, and T.E. Nickelson. 2005. Effects of an increase in large wood on abundance and survival of juvenile salmonids (Oncorhynchus spp.) in an Oregon coastal stream. Canadian Journal of Fisheries and Aquatic Sciences 62: 412-424.

Jong, B, M. Gilroy, and L. Preston. No date. North Coast CA Coho Salmon Investigation (NCCCSI). Unpublished data, California Department of Fish and Game, Eureka, CA.

Justice, C. 2007. Response of juvenile salmonids to placement of large woody debris in California coastal streams. A Thesis Presented to The Faculty of Humboldt State University, Arcata, CA.

Kahler, T.H., P. Roni, and T.P. Quinn. 2001. Summer movement and growth of juvenile anadromous salmonids in small western Washington streams. Canadian Journal of Fisheries and Aquatic Sciences 58:1947-1956.

Keller, E.A., and F.J. Swanson. 1979. Effects of large organic material on channel form and fluvial processes. Earth Surface Processes 4: 361-380.

Klein, R.D. 2007. Hydrologic assessment of low flows in the Mattole River basin, 2004-2006. Report to Sanctuary Forest, Inc. 22 pp.

Klein, R.D. 2009. Hydrologic assessment of low flows in the Mattole River basin, 2004-2008. Report to Sanctuary Forest, Inc. 24 pp.

Klein, R.D., W.J. Trush, and M. Buffleben. 2008. Watershed condition, turbidity, and implications for anadromous salmonids in north coastal California streams. Report to North Coast Regional Water Quality Control Board, Santa Rosa, CA. 105 pp.

Kondolf, G.M. 2000. Assessing salmonid spawning gravel quality. Transactions of the American Fisheries Society 129:262-281.

Koski, K.V. 2009. The fate of coho salmon nomads: the story of an estuarine-rearing strategy promoting resilience. Ecology and Society 14(1): 4. (http://ecologyandsociety.org/vol14/iss1/art4/)

Kramer, A.M, B. Dennis, A.M. Liebhold, and J.M. Drake. 2009. The evidence for Allee effects. Population Ecology 51(3): 341-354.

Lesica, P., and F.W. Allendorf . 1995. When are peripheral populations valuable for conservation? Conservation Biology 9(4): 753-760.

Lestelle, L.C. 2007. Coho Salmon (*Oncorhynchus kisutch*) life history patterns in the Pacific Northwest and California. Report prepared for U.S. Bureau of Reclamation, Klamath Area Office, by Biostream Environmental, Poulsbo, WA. 122 pp.

Lisle, T.E. 1989. Sediment transport and resulting deposition in spawning gravels, north coastal California. Water Resources Research 25(6): 1303-1319. http://www.fs.fed.us/psw/publications/lisle/Lisle89.pdf

MacFarlane R.B., S. Hayes, and B. Wells. 2008. Coho and Chinook salmon decline in California during the spawning seasons of 2007/08. Unpublished document from the National Oceanic and Atmospheric Administration Southwest Fisheries Science Center, Santa Cruz, CA.

Mattole Restoration Council (MRC). 2008. Stream channel monitoring using CDFG “core attributes” protocols: Mattole River watershed, 2005 and 2007. Petrolia, CA. 34 pp.

Mattole Restoration Council (MRC), Mattole Salmon Group, Sanctuary Forest, Bureau of Land Management and State Coastal Conservancy. 2005. Mattole Watershed Plan. Petrolia, CA. 920 pp.

Mattole River and Range Partnership (MRRP). 2009a. Mattole Integrated Coastal Watershed Management Plan Foresight 2020. Petrolia, California.

Mattole River and Range Partnership (MRRP). 2009b. Riparian Ecosystem Restoration: Number 7 in the 2009 State of the Mattole Watershed Series, Companion to the Mattole Integrated Coastal Watershed Management Plan. Petrolia, California. 22 pp.

Mattole River and Range Partnership (MRRP). 2009c. Sediment: Number 4 in the 2009 State of the Mattole Watershed Series, Companion to the Mattole Integrated Coastal Watershed Management Plan. Petrolia, California. 25 pp.

Mattole Salmon Group (MSG). 2000. Five-year management plan for salmon stock rescue operations: 2000-2001 through 2004-2005 seasons. Mattole Salmon Group, Petrolia, CA. 36 pp.

Mattole Salmon Group (MSG). 2009. Salmonid Population Monitoring Plan. Petrolia, CA.

May, C.L., and D.C. Lee. 2004. The Relationships among in-channel sediment storage, pool depth, and summer survival of juvenile salmonids in Oregon Coast Range streams. North American Journal of Fisheries Management, 24: 761-774.

McCoy, B.L. 2008. Effect of rearing location on escapement of coho salmon (*Oncorhynchus kistuch*) at Freshwater Creek, California. A Thesis Presented to The Faculty of Humboldt State University. November 2008.

McElhany, P., M.H. Ruckelshaus, M.J. Ford, T.C.Wainwright, and E.P. Bjorkstedt. 2000. Viable salmonid populations and the recovery of evolutionarily significant units. U.S. Dept. Commer., NOAA Tech. Memo. NMFS-NWFSC-42, 156 p.

McElhany, P., T. Backman, C. Busack, S. Heppell, S. Kolmes, A. Maule, J. Myers, D. Rawding, D. Shively, A. Steel, C. Steward, and T. Whitesel. 2003. Interim report on viability criteria for Willamette and lower Columbia basin Pacific salmonids. Willamette/Lower Columbia Technical Recovery Team report, March 31, 2003, NOAA Fisheries, Northwest Fisheries Science Center, Seattle WA. <http://www.nwfsc.noaa.gov/trt/wlc/viability_criteria.cfm>

McKee, T. 2004a. Options and obstacles: living with low water flows in the Mattole River Headwaters. Sanctuary Forest, Whitethorn, CA, November 2004.

McKee, T. 2004b. Upper Mattole River Water Diversion/ Fish Passage/ Low Flow Survey, August 23 & 24, 2004. Unpublished notes.

McMahon, T.E., and G.F. Hartman. 1989. Influence of cover complexity and current velocity on winter habitat use by juvenile coho salmon (Oncorynchus kisutch). Canadian Journal of Fisheries and Aquatic Sciences 46: 1551-1557.

McNeil, W.J., and W.H. Ahnell. 1964. Success of pink salmon spawning relative to size of spawning bed material. U.S. Fish and Wildlife Service, Special Scientific Report - Fisheries No. 469. Washington, D.C. 17 pp.

Montgomery, D.R., and J.M. Buffington. 1998. Channel Processes, classification, and response. Pages 13-42 in R. J. Naiman and R. E. Bilby, editors. River ecology and management: lessons from the Pacific coastal ecoregion. Springer-Verlag, New York, N.Y., USA.

Moyle, P.B., J.A. Israel, and S.E. Purdy. 2008. Salmon, steelhead, and trout in California: status of an emblematic fauna. UC Davis Center for Watershed Sciences. 316 pp.

National Marine Fisheries Service (NMFS). 2001. Southern Oregon/Northern California Coast Coho ESU. NOAA's National Marine Fisheries Service Southwest Regional Office. Updated 2005. (http://www.swr.noaa.gov/recovery/Coho_SONCCC.htm)

National Marine Fisheries Service (NMFS). 2006. NMFS Interim Recovery Planning Guidance. Silver Spring, Maryland. http://www.nmfs.noaa.gov/pr/pdfs/recovery/guidance.pdf.

National Marine Fisheries Service (NMFS). 2010. CCC Coho Salmon ESU Draft Recovery Plan. National Marine Fisheries Service, Southwest Region, Santa Rosa, California.

Nickelson, T.E. 1998. A habitat-based assessment of Coho salmon production potential and spawner escapement needs for Oregon coastal streams. Oregon Department of Fish and Wildlife Information Report Number 98-4. April, 1998, Portland, OR.

Nickelson, T.E., M.F. Solazzi, S.L. Johnson, and J.D. Rodgers. 1992a. Effectiveness of selected stream improvement techniques to create suitable summer and winter rearing habitat for juvenile coho salmon (Oncorhynchus kisutch) in Oregon coastal streams. Canadian Journal of Fisheries and Aquatic Sciences 49: 790–794.

Nickelson, T.E., Rodgers, J.D., S.L. Johnson, and M.F. Solazzi. 1992b. Seasonal changes in habitat use by juvenile coho salmon (Oncorhynchus kisutch) in Oregon coastal streams. Canadian Journal of Fisheries and Aquatic Sciences 49:783-789.

Obedzinski, M., D.J. Lewis, P.G. Olin, and J.C. Pecharich. 2008. Survival and growth of coho salmon released into Russian River tributaries: Russian River Coho Salmon Captive Broodstock Program monitoring component results October 2004 through June 2007. University of California Cooperative Extension and California Sea Grant Program. Santa Rosa, California.

Obedzinski, M., J.C. Pecharich, J.A. Davis, S. Nossaman, P.G. Olin, and D.J.Lewis. 2009. Russian River Coho Salmon Captive Broodstock Program Monitoring Activities: Annual Report, July 2007 to June 2008. University of California Cooperative Extension and Sea Grant Program. Santa Rosa, California.

Parenskiy, V.A. 1990. Relation between the spawning success of sockeye salmon, *Oncorhynchus nerka*, and behavior on spawning grounds. Journal of Ichthyology 30:48–58.

Pert, H.A. 1993. Winter Food Habits of Coastal Juvenile Steelhead and Coho Salmon in Pudding Creek, Northern California. Unpublished Master’s Thesis, University of California, Berkeley, CA. 65 pp.

Pincetich C., T. Steiner, and P. Bouley. 2009. Evaluation of coho and steelhead production in the San Geronimo Valley headwaters of Lagunitas Creek watershed 2006-2008. Salmon Protection and Watershed Network. Forest Knolls, California.

Pincetich, C., T. Steiner, and P. Bouley. 2010. Coho and steelhead smolt outmigration from the San Geronimo Valley, Marin County, 2009. Salmon Protection and Watershed Network. Forest Knolls, California.

Pollock, M.M., G.R. Pess, T.J. Beechie, and D.R. Montgomery. 2004. The importance of beaver ponds to coho salmon production in the Stillaguamish River basin, Washington, USA. North American Journal of Fisheries Management 24:749-760.

Preston, L., M. Gilroy, and B. Jong. 2002. Coho salmon presence/absence modified ten-pool survey protocol. California Department of Fish and Game Northern California - North Coast Region.

Quinn, T.P., and N.P. Peterson. 1996. The influence of habitat complexity and fish size on over-winter survival and growth of individually marked juvenile coho salmon (Oncorhynchus kisutch) in Big Beef Creek, Washington. Canadian Journal of Fisheries and Aquatic Sciences 53(7): 1555-1564.

Quinn, T.P., B.R. Dickerson, and L.A. Vollestad. 2005. Marine survival and distribution patterns of two Puget Sound hatchery populations of coho (Oncorhynchus kisutch) and chinook (Oncorhynchus tshawytscha) salmon. Fisheries Research 76(2): 209-220.

Richardson, J.S., R.E. Bilby, and C.A. Bondar. 2005. Organic matter dynamics in small streams of the Pacific Northwest. Journal of the American Water Resources Association 41(4): 921-934.

Ricker, S.J. 2006. Results of juvenile downstream migrant trapping conducted on Freshwater Creek, 2005. Anadromous Fisheries Resource Assessment and Monitoring Program, California Department of Fish and Game.

Ricker, S.J. 2008. Results of juvenile downstream migrant trapping conducted on Freshwater Creek, 2007. Anadromous Fisheries Resource Assessment and Monitoring Program, California Department of Fish and Game.

Roni, P., and T. P. Quinn. 2001. Density and size of juvenile salmonids in response to placement of large woody debris in western Oregon and Washington streams. Canadian Journal of Fisheries and Aquatic Sciences 58:282–292.

Rosenfeld, J.S., and L. Huato. 2003. Relationship between large woody debris characteristics and pool formation in small coastal British Columbia streams. North American Journal of Fisheries Management 23:928–938.

Scudder, G.G.E. 1989. The adaptive significance of marginal populations: a general perspective. Pp. 180–185 in C. D. Levings, L. B. Holtby, and M. A. Henderson, eds. Proc. of national workshop on effects of habitat alteration on salmonid stocks. Canadian Special Publication of Fisheries and Aquatic Sciences 105:180–185.

Smith, J.J. 2001. Distribution and abundance of juvenile coho and steelhead in Gazos Creek. Department of Biological Sciences, San Jose State University. Unpublished report, 12 pp.

Solazzi, M.F., T.E. Nickelson, S.L. Johnson, and J.D. Rodgers. 2000. Effects of increasing winter rearing habitat on abundance of salmonids in two coastal Oregon streams. Canadian Journal of Fisheries and Aquatic Sciences 57: 906–914.

Sparkman, M.D. 2009. Lower Redwood Creek Juvenile Salmonid (smolt) downstream migrant study, study year 2008 annual report. Anadromous Fisheries Resource Assessment and Monitoring Program, California Department of Fish and Game.

Spence, B.C., G.A. Lomnicky, R.M. Hughes, and R.P. Novitzki. 1996. An ecosystem approach to salmonid conservation. TR-4501-96-6057. ManTech Environmental Research Services Corp., Corvallis, OR. (Available from the National Marine Fisheries Service, Portland, Oregon.)

Stillwater Sciences. 2006. Mill Creek fisheries monitoring program: ten year report. Final report. Prepared by Stillwater Sciences, Arcata, CA, for Department of Fish and Game and Save the Redwoods League, San Francisco, CA.

Stillwater Sciences. 2008. Lagunitas limiting factors analysis; limiting factors for coho salmon and steelhead. Final report. Prepared by Stillwater Sciences, Berkeley, CA for Marin Resource Conservation District, Point Reyes Station, CA.

Stillwater Sciences. 2009. Lagunitas Creek 2009 downstream migrant report. Draft Report. Prepared by Stillwater Sciences, Berkeley, CA for Marin Municipal Water District, Corte Madera, CA.

Sutton, R., and T. Soto. 2010.Juvenile coho salmon behavioral characteristics in Klamath River summer thermal refugia. River Research and Applications. Pre-print version, published online in Wiley Online Library.

U.S. Fish and Wildlife Service (USFWS). 2008. Draft rotary screw trap protocol for estimating production of juvenile Chinook salmon. Document prepared by the U.S. Fish and Wildlife Service, Comprehensive Assessment and Monitoring Program. Sacramento, CA. 44 pp.

U. S. Geological Survey (USGS). 2010. Water-Data Report 2009: 11468900 Mattole River near Ettersburg, CA. U.S. Geological Survey, U.S. Department of the Interior. 7 pp. http://wdr.water.usgs.gov/wy2009/pdfs/11468900.2009.pdf

Wallace, M. 2010. Wood creek field notes. January 25, 2010. California Department of Fish and Game, Eureka, CA.

Waples, R. 1991. Genetic interactions between hatchery and wild salmonids: lessons from the Pacific Northwest. Canadian Journal of Fisheries and Aquatic Sciences 48(1):124–133.

Waples, R.S., and C. Do. 1994. Genetic risk associated with supplementation of Pacific salmonids: Captive broodstock programs. Canadian Journal of Fisheries and Aquatic Sciences 51(1):310-329.

Weitkamp, L.A., T.C. Wainwright, G.J. Bryant, G.B. Milner, D.J. Teel, R.G. Kope, and R.S. Waples. 1995. Status review of coho salmon from Washington, Oregon and California. U.S. Dep. Commerce, NOAA Tech. Memo. NMFS-NWFSC-24, 258p.

Welsh, H.H., G.R. Hodgson, B.C. Harvey, and M.F. Roche. 2001. Distribution of Juvenile Coho Salmon in Relation to Water Temperatures in Tributaries of the Mattole River, California. North American Journal of Fisheries Management 21:3, 464-470.

Wigington, P.J. Jr., J.L. Ebersole, M.E. Colvin, S.G. Leibowitz, B. Miller, B. Hansen, H.R. Lavigne, D. White, J.P. Baker, M.R. Church, J.R. Brooks, M.A. Cairns, and J.E. Compton. 2006. Coho salmon dependence on intermittent streams. Frontiers in Ecology and the Environment 4(10): 513-518.

Williams, T.H., and G.H. Reeves. 2003. Ecosystem diversity and the extinction risk of Pacific salmon and trout. Pages 107-115 *in* A. D. MacCall and T. C. Wainwright, editors. Assessing extinction risk for west coast salmonids. NOAA Technical Memorandum NMFS-NWFSC-56.

Williams, T.H., E.P. Bjorkstedt, W.G. Duffy, D. Hillemeier, G. Kautsky, T.E. Lisle, M. McCain, M. Rode, R.G. Szerlong, R.S. Schick, M.N. Goslin, and A. Agrawal. 2006. Historical population structure of coho salmon in the Southern Oregon / Northern California coasts evolutionarily significant unit. NOAA-NMFS-SWFSC-390. Santa Cruz, CA.

Williams, T.H., B.C. Spence, W. Duffy, D. Hillemeier, G. Kautsky, T.E. Lisle, M. McCain, T.E. Nickelson, E. Mora, and T. Pearson. 2008. Framework for assessing viability of threatened coho salmon in the Southern Oregon / Northern California coasts evolutionarily significant unit. NOAA-TM-NMFS-SWFSC-432. Santa Cruz, CA. December 2008.

Wondzell, S.M., and P.A. Bisson. 2003. Influence of wood on aquatic biodiversity. American Fisheries Society Symposium 37:249-263.

Woodsmith, R.D., and J.M. Buffington. 1996. Multivariate geomorphic analysis of forest streams: implications for assessment of land use impacts on channel condition. Earth Surface Processes and Landforms 21:377-393.

Woodsmith, R.D., and F.J. Swanson. 1997. The influence of large woody debris on forest stream geomorphology. In: Wang, S.S.Y., E.J. Langedoen, F.D.J. Shields (Eds): Management of landscapes disturbed by channel incision. University of Mississippi, Oxford, MS, pp. 133-138.

Wooster, J. 2000. Compilation of Stream Cleaning Data in the North Coast, CA. http://www.krisweb.com/biblio/ncc_cdfg_wooster_xxxx_streamcleaning.htm

Appendix A

Mattole Salmon Group Spawning Ground Survey Data 1994-2010

Survey Reach	Total Years Surveyed	Total Years coho redds	Total All Years			2009-2010			2008-2009			2007-2008			2006-2007		
Mainstem Mattole River			Live Fish	Carcasses	Redds	L	C	R	L	C	R	L	C	R	L	C	R
Mattole headwaters index	16	15	137	70	96	2	0	0	2	0	2	4	2	7	9	1	1
Whitethorn area to Thorn	13	6	36	11	7	0	0	0	0	0	0	2	0	2	2	0	0
Thorn Junction index reach	16	1	10	3	1	0	0	0	0	0	0	3	0	0	0	0	0
Big Finley Creek to	14	2	25	2	8	0	0	0	0	0	0	1	0	0	2	0	0
Ettersburg to Honeydew	12	1	30	1	1				0	0	0	9	0	0	2	0	0
Honeydew to A. Way Cnty.	12	0	62	0	0	0	0	0	9	0	0	18	0	0	2	0	0
Mainstem Totals			**300**	**87**	**113**	**2**	**0**	**0**	**11**	**0**	**2**	**37**	**2**	**9**	**17**	**1**	**1**
Tributaries																	
Lost River	1	0	0	0	0												
Ancestor Creek: Conf	2	2	2	0	3							0	0	2			
Helen Barnum Creek	1	0	0	0	0												
Danny's Cr.	15	12	35	11	63	1	0	1	0	0	0	1	0	1	5	2	5
Yew Cr	16	10	20	3	36	0	0	0	0	0	0	2	0	6	1	0	2
Thompson Cr	16	14	74	23	92	0	0	0	0	0	0	3	2	7	2	2	2
Baker Cr	15	9	31	4	21	0	0	0	0	0	0	2	0	2	3	0	1
Stanley Cr.	1	0	0	0	0												
Upper Mill Cr.	12	8	7	4	20	0	0	0	0	0	4	2	0	2	0	0	1
Vanauken Cr.	7	1	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0
McKee Cr.	11	4	4	0	10	0	0	0	0	0	3	0	0	0	0	0	1
Bridge Cr.	16	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Eubanks Cr.	13	0	0	0	0				0	0	0	0	0	0			
Big Finley Creek	2	0	0	0	0												
S. Fk Bear Cr.: Shelter Cove Rd Upstream	15	8	24	8	49	0	0	0	0	0	0	5	0	2	0	0	3
S. Fk Bear Cr.: Lingel/Brown Br. - Shelter Cove Rd.	15	2	8	3	6	0	0	0	0	0	0	0	0	0	0	0	0
S. Fk Bear Cr. : Tolkan CG to Queen Mine Rd.	7	2	3	1	3	0	0	0							1	1	2
S. Fk Bear Cr.: Horse Mt. CG to Tolkan CG	12	1	0	1	1				0	0	0	0	0	0			
North Fork Bear Creek	2	0	0	0	0												
Bear Cr.: conf. w/ Mattole to Jewett Cr.	11	1	4	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Mattole Canyon Cr.	4	0	0	0	0				0	0	0	0	0	0			
Fourmile Cr	3	0	0	0	0				0	0	0	0	0	0			
Lower East Fk Honeydew	6	0	0	0	0							0	0	0			
Honeydew Creek	11	0	0	0	0							0	0	0	0	0	0
Bear Trap Creek	3	0	0	0	0												
Rattlesnake Cr.	3	0	0	0	0				0	0	0	0	0	0			
Squaw Creek	5	0	0	0	0												
Indian Creek	3	0	0	0	0												
Clear Cr.	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lower North Fork	1	0	0	0	0												
McGinnis Cr	2	0	0	0	0				0	0	0						
East Mill Cr.	5	0	0	0	0	0	0	0	0	0	0	0	0	0			
Lower Mill Cr.	16	2	0	0	0	0	0	0	0	0	0	0	0	0			
Tributary Totals			**213**	**58**	**307**	**1**	**0**	**1**	**0**	**0**	**7**	**15**	**2**	**22**	**12**	**5**	**17**
All Totals			**513**	**145**	**420**	**2**	**0**	**0**	**11**	**0**	**9**	**52**	**4**	**31**	**29**	**6**	**18**

Appendix A

Mattole Salmon Group Spawning Ground Survey Data 1994-2010

Survey Reach	**2005-2006**			**2004-2005**			**2003-2004**			**2002-2003**			**2001-2002**			**2000-2001**		
Mainstem Mattole River	**L**	**C**	**R**	**L**	**C**	**R**	**L**	**C**	**R**	**L**	**C**	**R**	**L**	**C**	**R**	**L**	**C**	**R**
Mattole headwaters index reach	8	3	3	13	20	18	17	6	4	14	0	4	32	28	16	5	2	9
Whitethorn area to Thorn Jct.	15	0	0	7	1	2	0	0	0	3	4	1	5	4	0	0	0	0
Thorn Junction index reach	0	0	0	0	0	1	0	0	0	0	2	0	0	1	0	3	0	0
Big Finley Creek to Ettersburg	1	0	0	11	0	0	0	0	0				0	0	0	0	1	1
Ettersburg to Honeydew	5	1	0	10	0	0				1	0	0				2	0	1
Honeydew to A. Way Cnty. Park	4	0	0	11	0	0				18	0	0				0	0	0
Mainstem Totals	**33**	**4**	**3**	**52**	**21**	**21**	**17**	**6**	**4**	**36**	**6**	**5**	**37**	**33**	**16**	**10**	**3**	**11**
Tributaries																		
Lost River																		
Ancestor Creek: Conf w Mattole	2	0	1															
Helen Barnum Creek																		
Danny's Cr.	8	3	5	5	2	14	2	1	6	4	2	7	8	0	10	0	0	0
Yew Cr	0	0	0	0	0	6	0	0	2	4	0	2	5	0	9	0	3	2
Thompson Cr	4	2	3	18	3	19	10	2	13	9	2	6	13	4	12	0	0	2
Baker Cr	0	0	1	1	3	2	13	0	4	0	0	0	5	1	6	4	0	2
Stanley Cr.				0	0	0												
Upper Mill Cr.	0	0	1	2	0	3	0	4	6	3	0	2	0	0	0	0	0	0
Vanauken Cr.	0	0	0	0	0	0	0	0	2									
McKee Cr.	0	0	0	4	0	3	0	0	3	0	0	0	0	0	0	0	0	0
Bridge Cr.	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Eubanks Cr.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
Big Finley Creek							0	0	0									
S. Fk Bear Cr.: Shelter Cove Rd Upstream	0	1	0	0	0	0	0	0	2	8	2	8	0	0	0	0	0	0
S. Fk Bear Cr.: Lingel/Brown Br. - Shelter Cove Rd.	0	2	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
S. Fk Bear Cr. : Tolkan CG to Queen Mine Rd.	1	0	0													0	0	0
S. Fk Bear Cr.: Horse Mt. CG to Tolkan CG	0	0	1							0	0	0	0	0	0	0	0	0
North Fork Bear Creek																		
Bear Cr.: conf. w/ Mattole to Jewett Cr.							0	0	0	0	0	0				0	0	0
Mattole Canyon Cr.							0	0	0									
Fourmile Cr																		
Lower East Fk Honeydew Creek				0	0	0												
Honeydew Creek	0	0	0	0	0	0	0	0	0							0	0	0
Bear Trap Creek																		
Rattlesnake Cr.				0	0	0												
Squaw Creek				0	0	0										0	0	0
Indian Creek				0	0	0	0	0	0				0	0	0			
Clear Cr.	0	0	0	0	0	0	0	0	0									
Lower North Fork	0	0	0															
McGinnis Cr				0	0	0												
East Mill Cr.	0	0	0	0	0	0	0	0	0									
Lower Mill Cr.	0	0	0	0	0	0	0	0	0				0	0	0	0	0	0
Tributary Totals	**16**	**8**	**12**	**32**	**8**	**47**	**25**	**7**	**38**	**28**	**6**	**25**	**31**	**5**	**37**	**4**	**3**	**6**
All Totals	**49**	**12**	**15**	**84**	**29**	**68**	**42**	**13**	**42**	**64**	**12**	**30**	**68**	**38**	**53**	**14**	**6**	**17**

Appendix A

Mattole Salmon Group Spawning Ground Survey Data 1994-2010

Survey Reach	1999-2000			1998-1999			1997-1998			1996-1997			1995-1996			1994-1995		
Mainstem Mattole River	L	C	R	L	C	R	L	C	R	L	C	R	L	C	R	L	C	R
Mattole headwaters index reach	7	0	7	2	2	4	9	3	12	8	1	2	3	0	2	4	2	5
Whitethorn area to Thorn Jct.	2	0	2	0	2	0							0	0	0			
Thorn Junction index reach	3	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Big Finley Creek to Ettersburg	10	0	7	0	1	0	0	0	0				0	0	0	0	0	0
Ettersburg to Honeydew	0	0	0	0	0	0	0	0	0				1	0	0	0	0	0
Honeydew to A. Way Cnty. Park	0	0	0	0	0	0							0	0	0	0	0	0
Mainstem Totals	**22**	**0**	**16**	**3**	**5**	**4**	**9**	**3**	**12**	**8**	**1**	**2**	**4**	**0**	**2**	**4**	**2**	**5**
Tributaries																		
Lost River																0	0	0
Ancestor Creek: Conf w Mattole																		
Helen Barnum Creek																0	0	0
Danny's Cr.	1	1	3	0	0	0	1	0	3	0	0	8				0	0	1
Yew Cr	0	0	1	0	0	0	6	0	5	0	0	0	0	0	0	2	0	1
Thompson Cr	0	1	1	6	1	2	3	0	5	2	3	8	4	0	5	0	1	7
Baker Cr	0	0	0	0	0	0	2	0	2	1	0	1				0	0	0
Stanley Cr.																		
Upper Mill Cr.	0	0	0	0	0	1												
Vanauken Cr.																		
McKee Cr.				0	0	0												
Bridge Cr.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Eubanks Cr.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Big Finley Creek				0	0	0												
S. Fk Bear Cr.: Shelter Cove Rd Upstream	2	0	1	0	0	1	0	0	3	9	5	29	0	0	0	0	0	0
S. Fk Bear Cr.: Lingel/Brown Br. - Shelter Cove Rd.	0	0	0	5	0	0	1	0	4	0	1	2	0	0	0	0	0	0
S. Fk Bear Cr. : Tolkan CG to Queen Mine Rd.	1	0	1															
S. Fk Bear Cr.: Horse Mt. CG to Tolkan CG	0	0	0	0	0	0	0	0	0	0	1	0						
North Fork Bear Creek	0	0	0	0	0	0	0	0	0	0	0	0						
Bear Cr.: conf. w/ Mattole to Jewett Cr.	3	0	0							0	0	0	0	0	0	1	0	1
Mattole Canyon Cr.																0	0	0
Fourmile Cr																0	0	0
Lower East Fk Honeydew Creek				0	0	0	0	0	0				0	0	0	0	0	0
Honeydew Creek	0	0	0	0	0	0	0	0	0				0	0	0	0	0	0
Bear Trap Creek	0	0	0	0	0	0	0	0	0									
Rattlesnake Cr.																		
Squaw Creek	0	0	0	0	0	0	0	0	0							0	0	0
Indian Creek																		
Clear Cr.																		
Lower North Fork																		
McGinnis Cr																		
East Mill Cr.																		
Lower Mill Cr.	0	0	0	0	0	0												
Tributary Totals	**7**	**2**	**7**	**11**	**1**	**4**	**13**	**0**	**22**	**12**	**10**	**48**	**4**	**0**	**5**	**3**	**1**	**10**
All Totals	**29**	**2**	**23**	**14**	**6**	**8**	**22**	**3**	**34**	**20**	**11**	**50**	**8**	**0**	**7**	**7**	**3**	**15**

Appendix B

Mattole Salmon Group Snorkel Survey Data – # of juvenile coho observed by site and year

No Juvenile Snorkel Surveys were conducted in 2005. "N/A" indicates that either a spring or fall dive was not conducted, due to funding limitations, dry stream reach, or other reason.

Tributary Name/Location	RM	2010		2009		2008		2007		2006		2004		2003		2002		2001		2000	
		Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall
Lower Bear Creek	1+ ~0.3			0	0	0	0	0	0												
Stansberry Creek	1.3+0.1			0	0	0	0	0	0	0	0										
Lower Mill Creek (lower)	2.8+ ~0.1	0	0	0	0	11	0	4	0	1	0	0	0	8	0	0	N/A			0	0
Lower Mill Creek (upper)		0	0																		
Lower North Fork	4.7+~1.0			0	0	N/A	0	0	0	0	0										
Sulphur Creek (trib. to LNF)	4.7+~1.0+			0	0	0	0														
East Mill Creek (lower)	5.4 +0.2	0	0	0	0	0	0	0	0	4	0	1	N/A	1	0						
East Mill Creek (upper)		0	0																		
Clear Creek (lower)	6.1+0.2	0	0	0	0	0	0	0	0	1	0					0	0	0	N/A	0	N/A
Clear Creek (upper)		0	0																		
Conklin Creek	7.8+0.3					0	0	0	0	0	0									0	N/A
McGinnis Creek	8.0+0.1							0	N/A	N/A	0										
Squaw Creek (lower)	14.9+0.1	0	0	0	0	0	0	N/A	0	1	0										
Squaw Creek (upper)		0	0																		
Saunders Creek	19.9+ ~.3									0	0					0	0	0	0		
Woods Creek (lower)	24.1	0	0	0	0	0	0	3	2	8	0					0	0	0	2	N/A	N/A
Woods Creek (upper)		0	0																		
Upper North Fork	25.5+~1.0			0	0	0	0	0	0	0	0									0	N/A
Oil Creek	25.5 +2.0+~0.1							0	0												
Rattlesnake Creek	25.5 +2.0+~0.1			0	0																
Honeydew Creek (lower)	26.5+~1.0			0	0	0	0	0	0	0	0										
Honeydew Creek (upper)	26.5 + ~2.5			0	0	N/A	0	0	0	0	0										
Honeydew Creek (east fork)	26.5+~2.5+0.1			0	0	0	0	0	0												
Dry Creek	30.4+0.1															0	N/A	0	N/A	0	0

Appendix B

Mattole Salmon Group Snorkel Survey Data – # of juvenile coho observed by site and year

No Juvenile Snorkel Surveys were conducted in 2005. "N/A" indicates that either a spring or fall dive was not conducted, due to funding limitations, dry stream reach, or other reason.

Tributary Name/Location	RM	2010		2009		2008		2007		2006		2004		2003		2002		2001		2000	
		Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall
Middle Creek	31.3+0.2															0	N/A	0	N/A	0	0
Westlund Creek (upper)	31.7+ ~1.2															0	N/A			0	0
Westlund Creek (lower)	31.7+.01															0	N/A	0	0	0	0
Gilham Creek	32.8 +0.1							0	0												
Fourmile Creek (lower)	34.6+~0.1	0	0	0	0	0	0	0	3												
Fourmile Creek (upper)		0	0																		
Sholes Creek	36.6+~0.1			0	0	0	0	0	0												
Grindstone Creek	39.0+0.1			0	0			0	0											0	0
Mattole Canyon Creek (upper; shallow)	41.1+3.1			0	0	0	0									0	0	0	0		
Blue Slide Creek	42.0+0.1							0	N/A											0	N/A
Upper Bear Creek	42.8+ ~0.5	0	0	0	0	0	0	0	0			N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	N/A
N. Fork Bear Creek	42.8+~5.0+~2.0			0	0	0	0														
S. Fork Bear Creek	42.8+~5.0+~1.0			0	0	0	0	0	0												
S. Fork Bear Creek (Hidden Valley)		0	0																		
S. Fork Bear Creek (Wailaki)		0	0																		
Jewett Creek	42.8+~3.0+0.1							0	0												
Deer Lick Creek	45.9 + ~0.1							0	0												
Big Finley Creek (lower)	47.4+~0.1	0	0	0	0	13	1	0	0												
Big Finley Creek (upper)		0	0																		
Eubanks Creek (lower)	47.7+.1	0	0	0	0	0	0	0	0											0	0
Eubanks Creek (upper)		0	0																		
Bridge Creek (lower)	52.1+0.2	0	0	0	0	2	0	0	0			0	5	1	46	94	N/A			0	0
Robertson Creek	52.1+2.1	0	0									0	1	60	17	77	7				
Bridge Creek (WF)	52.1+2.15	0	0									0	0	0	13	22	4				

Appendix B

Mattole Salmon Group Snorkel Survey Data – # of juvenile coho observed by site and year

No Juvenile Snorkel Surveys were conducted in 2005. "N/A" indicates that either a spring or fall dive was not conducted, due to funding limitations, dry stream reach, or other reason.

Tributary Name/Location	RM	2010		2009		2008		2007		2006		2004		2003		2002		2001		2000	
		Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall
Van Arken Creek (upper)		0	0																		
Anderson Creek (lower)	55.6+~0.1					0	0					0	0	0	N/A	0	N/A				
Anderson Creek (upper)	55.6+0.35											0	0	0	N/A	0	N/A				
Upper Mill Creek (lower)	56.2+0.1	0	0	6	0	0	17	0	0			21	2	10	19	36	N /A				
Upper Mill Creek (upper)	56.2+1.4	0	0									24	40	58	48	9	N/A				
Baker Creek (lower)	57.6+0.01	0	0	18	0	127	0	71	0			25	3	45	16	152	0				
Baker Creek (upper)	57.6+0.95	0	0									41	67	9	3	108	4				
Thompson Creek (lower)	58.4+0.15	1	7	13	23	2	105	23	30			168	39	76	125	552	43			11	6
Thompson Creek (upper)	58.4+2.3	9	20									81	48	148	81	220	0				
NF Thompson Creek	58.4+2.2	7	5									75	103	96	68	123	14				
Yew Creek (lower)	58.4+ 0.15+ 0.1	0	0	15	20	14	19	87	45			31	9	95	42	81	15			1	12
Yew Creek (upper)	58.4+0.15+ 0.4	0	0									17	15	37	31	36	1				
Helen Barnum Creek (lower)	58.7+0.01	0	0					0	0			2	0	2	0	1	N/A				
Helen Barnum Creek (upper)	58.7+0.9	0	0									0	0	0	0	0	0				
Lost River (lower)	58.8+0.01	0	0	0	0	13	0	6	0			26	0	28	0	160	N/A				
Lost River (upper)	58.8+1.0	0	0									0	N/A	0	0	4	N/A				
McNasty Creek	60.8+0.02	0	0	0	0							11	3	66	22	42	N/A				
Ancestor Creek (lower)	60.8+0.15	11	16	0	2	1	28	38	1			72	82	74	53	66	N/A				
Ancestor Creek (upper)		0	0																		

Appendix B

Mattole Salmon Group Snorkel Survey Data – # of juvenile coho observed by site and year

MAINSTEM MONITORING SITES	River Mile	2010		2009		2008		2007		2006		2004		2003		2002		2001		2000	
		Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall
Lagoon (lower)	0.1	0	0																	0	0
Lagoon (upper H2O)	0.5	0	0			0	0	0	0	0	0	0	0	0	0	0	0	12	0	0	0
Lagoon @ structure	0.5	0	0	0	N/A	0	0			1	0										
Lagoon @ structure (deep)	0.5							0	0	"	0										
Lagoon @ Area 5	0.5	0	0			0	N/A														
Lagoon (LB channel)	0.5	0	0			0	N/A									0	0	0	0		
Upper Estuary (TL-2)	0.7	0	0	0	0	0	0	0	1	0	0										
Upper Estuary (TL-3)	0.7	0	0	0	0	0	0	"	"	0	0										
US Stansberry Cr	1.3			1	0	0	0														
US Lower Mill Cr	2.8									N/A	0	8	0	0	N/A						
Wingdam 1	2.9			0	0	0	0	0	N/A	N/A	0	10	0			0	0	0	0	0	0
Wingdam 1 (deep)	2.9	0	0			0	0	0	N/A	N/A	0		"	0	0	0	0	0	0	0	0
DS Titus Creek	3.3															0	0	0	0		
@ Quonset hut	3.3											2	0	0	0						
DS Tom Scott Creek	3.31											0	0	0	0						
@ Drewry Seep	3.5															0	0	0	0		
US Lower N. Fork	4.7			0	0																
US East Mill Cr	5.5	0	0	0	0	N/A	0														
US Clear Cr	6.1	0	0	0	0	0	0														
US Conklin Cr	7.8					0	0														
DS Buck Miner Cr (deep)	13.8													0	0						
@ Buck Cr(deep)	13.9											0	0	0	0						
US Buck Cr	14											0	0	0	0						
@ Grange (deep)	14.5															0	N/A	0	0		
@ Grange (shallow)	14.5															0	N/A	0	0		
A. W. Way Cnty Park	14.7															0	0			0	0
US Squaw Cr	15	0	0	0	0	0	0														
DS Saunders	19.9											1	0								
US Woods Cr	24.2	0	0	0	0	0	0														
US Upper N. Fork	25.5			0	0	0	0														
DS Bundle Prairie Creek (water)	25.2															0	0	N/A	0		
US Honeydew Cr	26.5			0	0	0	0														
DS Middle Creek	31.2															0	N/A	0	N/A		

Appendix B

Mattole Salmon Group Snorkel Survey Data – # of juvenile coho observed by site and year

MAINSTEM MONITORING SITES	River Mile	2010		2009		2008		2007		2006		2004		2003		2002		2001		2000	
		Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall
DS Middle Creek (Bette's Hole), 9-8ft	31.2															0	N/A	0	N/A		
US Fourmile Creek	34.6	0	0	0	0	N/A	0														
US Sholes Creek	36.6			0	0																
US Grindstone Creek	38.9			0	0	0	0														
DS Ettersburg Br	~42	0	0	0	0	N/A	0														
US Bear Creek	42.9			0	0	0	0														
@ Big Finley Cr (shallow)	47.3											0	0	0	11	0	0				
@ Big Finley Cr (deep)	47.4	0	0	0	0	0	0	0	N/A			0	0	"	"	0	0				
US Eubanks Cr	47.8	0	0	0	0	N/A	0	N/A	N/A												
US Nooning Cr	50.7																			0	0
MS-6, Mattole us Bridge Cr	52.2	0	0	0	0	0	0	0	0												
@ McKee Cr (Junction Hole)	52.9			0	0	0	0	0	N/A			0	0	0	0	0	0	0	0	0	0
@ McKee (deep)	52.9											0	0	0	0	0	0	0	0		
US Van Arken	54											21	0	20	N/A						
MS-5 (us Van Arken)	53.8	0	0	0	0	0	0	3	0												
US Anderson	55.8					0	15														
US Upper Mill Cr	56.3			2	2	0	0														
Metz Br	56.9	0	0	0	N/A	0	0	12	10	N/A	N/A	46	N/A	202	51	390	N/A				
DS Gibson Creek (deep)	56.7																	6	19		
DS Gibson Creek (shallow)	56.7																	N/A	1	31	6
US Stanley Cr (MS-4)	57.1									N/A	N/A							N/A	72		
US Baker Cr	57.8	0	0	2	18	0	0	6	7												
US Thompson Cr (MS-3)	58.5	0	0	0	0	0	0	2	5	N/A	N/A										
MS-2	58.9	0	0	0	1	12	30	2	0									N/A	1		
US Pipe Creek (water)	59.6															288	N/A	0	2	1	6
US Pipe Creek (air)	59.6															"	"			"	"
MS-1	59.4	0	0	0	0	2	5	3	2	N/A	N/A										
Mattole below Mercer	55.1											0	3	0	0	0	N/A				
Mattole DS Ancestor Creek	60.8	1	0	0	0	0	15														

Appendix C

Summary of Work Completed by MRRP Groups to Address Tasks in *Recovery Strategy for California Coho Salmon* (CDFG 2004)

Task ID (CDFG 2004)	Description	Work completed by MRRP Groups Through 2009
8.1.12 Cape Mendocino Hydrologic Unit		
CM-HU-01	Supplement ongoing efforts to provide short-term and long-term benefits to coho salmon by restoring LWD and shade by the placement of LWD in stream channels to improve channel structure and function.	**See Southern and Western Subbasins, below.**
CM-HU-02	Assess and prioritize sources of excess sediment including roads.	**Sediment reduction work listed by subbasin, below**
CM-HU-03	Treat sources of excess sediment, including roads.	**MSG** – Constructed 4 lower mainstem bank stabilization projects incorporating both riprap and LWD cover: 3 in the estuary subbasin (Wing dams 1-3), and 1 in the western subbasin near Green Fir Road.
CM-HU-04	Investigate the feasibility of restoring estuarine function to maximize habitat for coho salmon.	**MSG** – Worked extensively in the estuary/lagoon monitoring existing conditions and planning for actions to address those conditions. Estuarine temperature monitoring has occurred annually in the summer months since 1995. Conducted multi-parameter water quality monitoring utilizing datasonde stations and roving surveys in conjunction with salmonid dives in the estuary since 2006. Monitoring programs determine which areas of the estuary/lagoon juvenile salmonids utilize, which areas provide suitable habitat, and which areas may be in need of improvement in order to prioritize restoration sites.
CM-HU-06	Conduct an inventory and prioritize for treatment migration coho salmon barriers other than county culverts.	**See work listed by subbasin, below.**

Appendix C
Summary of Work Completed by MRRP Groups to Address Tasks in *Recovery Strategy for California Coho Salmon* (CDFG 2004)

Task ID (CDFG 2004)	Description	Work Completed by MRRP Groups Through 2009
8.1.12.1 Southern Subbasin Mattole River HAS		
CM-MS-01	Encourage elimination of unnecessary and wasteful use of water to improve stream surface flows and coho salmon habitat through outreach and education of water and conservation practices.	**MSG** – Collaborated with SFI providing consultation and data for identification and prioritization of coho salmon reaches, updates on flow conditions in stream reaches not monitored by SFI, participation in the annual SFI stream hike and participation in the Local Water Advisory Group representing local fishery interests, and consultations with local residents. **SFI** – Mattole Flow Program: Water User Education in the Mattole Headwaters Project developed and distributed publications to residents of the Mattole River headwaters, radio talk shows, public service announcements, and SFI website updates. Conducted meetings with institutions in the headwaters regarding water conservation and water use assessments; four of the institutions later completed assessments with the use of water meters. Prepared institutional water use questionnaire to estimate water use and efficiency, storage capacity, water source, diversion system and fisheries protections. Following data collection, recommendations were made for water storage and fisheries protections needed to facilitate institutional water storage and forbearance. Education and Outreach also included two outreach brochures, a household water use inventory, and two community meetings to encourage participation in water conservation and develop solutions with the community. Donations from community members in 2005 funded a River Conference with Chris Maser.

CM-MS-02	Ensure protection of the high quality habitat found in the Mattole River headwaters and historic coho salmon streams.	**MSG** – Headwaters monitoring includes multi-parameter water quality monitoring and salmonid dives to monitor at-risk rearing salmonids. All salmonid-bearing streams in the southern subbasin have hourly temperature monitors throughout the summer and multi-parameter water quality spot-checks at placement and retrieval of the temperature monitoring devices. Data is used to determine when and if salmonid rescue is necessary and to quantify risks to survival both over each season and over multiple years. Monitoring provides essential information for coho salmon protection and conservation. **SFI** – Completed draft groundwater management plan for the headwaters. A local advisory group was formed in 2008 to provide input and guide development of the plan, whose members included local residents, timber and agricultural producers, business owners, and experts in fisheries, wildlife and fire protection. The document was finalized in July 2010, and was submitted to Humboldt County for a formal public review process. Also currently working on groundwater feasibility studies, reports, and permitting requirements; aggressive species control; and USGS data analysis.
CM-MS-03	Protect high quality habitat found in the South Fork of Vanauken, Mill, Stanley, Thompson, Yew, and Lost Man creeks through recognition of current land management practices and encourage private landowners to continue land stewardship.	**MSG** – Provided numerous consultations with local residents as requested by landowners and other restoration groups. Many landowners allow MSG to access their property to provide water quality and temperature monitoring. MSG provides water quality data and fish observation information to landowners to guide them in the best possible management decisions with regard to salmonid habitat on their property. **SFI** – Developed the Metz easement along Thompson Creek in 2000. SFI regularly monitors easement and encourages landowner to continue sediment reduction projects, forest thinning, water conservation, streamflow enhancement, and groundwater recharge projects into the future.
CM-MS-04	Promote a cooperative effort to establish monitoring stations at appropriate locations to monitor in-channel sediment (or turbidity) both in the lower basin and in the lower reaches of major tributaries.	**MRC –** Completed channel monitoring of 20 stream reaches in the Southern Subbasin in 2005 using CDFG "core attributes" protocols.
CM-MS-05	Support the assessment of sources of excess sediment.	**MRC** – Identified and prioritized approximately 300 sediment sources in southern subbasin. .

CM-MS-06	Support the prioritization and treatment of sources of excess sediment.	**MRC** – Treated 199 sediment sources along roads (175 sites) and streambanks (24 sites) for a total sediment savings of 68,875 cubic yards. **SFI** – Upper Mattole River Watershed Rehabilitation Project provided for sediment removal; stream bank and channel stabilization; tree planting; fish habitat enhancement; riparian zone clean-up; mulching; monitoring; public outreach; and technical review and pre-implementation planning in both Humboldt and Mendocino counties
CM-MS-10	Work with University of California Cooperative Extension (UCCE) specialists to monitor summer water and air temperatures and flow in cooperation with landowners using Department-accepted protocols.	**MSG** – Temperature monitoring program in the Mattole mainstem and salmonid-bearing tributaries throughout the watershed. Since 2000, 152 sites have been monitored for water and/or air temperatures during the critical summer months, when temperatures represent a major limiting factor to salmonid abundance and survival. Protocols used include DFG's 10-pool protocol. **SFI** – Worked with UC Berkeley graduate student and MSG on comprehensive study evaluating the effects of summer stream drying on populations of juvenile salmonids in the upper Mattole River in 2007-2008. Monitored streamflow and groundwater in the mainstem and tributaries since 2004 to acquire streamflow measurement data as required for the development and implementation of streamflow improvement projects. Streamflow monitoring procedures meet DFG protocols and were designed by Randy Klein, who trained SFI staff. SFI worked with cooperating landowners in the southern subbasin to establish monitoring sites, collected pre-implementation critical reach data, and collected mainstem data during the 2007 and 2008 dry season. SFI staff then used site data from the downstream end of the headwaters to update the public on river conditions through an informative roadside sign at Thorn Junction, radio public service announcements, and SFI website postings. Measurements were also taken at 15 tributary sites three times during the dry season (once at the beginning of the low flow season, once at the middle and once at the end). Five automated pressure transducer-data loggers were installed at mainstem sites in 2007 and 2008 to provide continuous streamflow data, and additional measurements of dissolved oxygen and temperature were taken. Eight downstream tributaries were monitored in 2008. The project was a coordinated effort between SFI, DFG, USFWS, SWRCB, and the McLean Foundation
CM-MS-11	Continue and expand on-going temperature monitoring efforts.	See CM-MS-10, above.

CM-MS-14	Provide incentives to landowners to protect coho salmon habitat and reduce water use.	**SFI** – *Mattole Water Storage and Forbearance Phase I Project* and *Water Storage and Forbearance for Salmonid Recovery Program* installed nine large capacity water tanks and developed forbearance agreements on seven properties with existing pre-project diversions. The development of a Water Management Plan was also completed for each participating landowner, including specific guidelines for water management and withdrawals. Additionally, the projects imposed a no-pump season and upgraded the existing diversions with fish screens that comply with DFG criteria, all in order to improve streamflow. An additional five tanks were installed by the end of 2010.
CM-MS-15	Develop educational materials for landowners explaining how they can protect coho salmon.	**MSG** – Worked closely with SFI in the preparation of materials on water storage and conservation and its impact on coho salmon as well as other aquatic species. **SFI** – *Mattole Headwaters Water Storage Education for Salmonid Recovery Project* provided Mattole River Watershed landowners with a manual offering key educational information in regards to sufficient water storage and the protection of salmonids where diversions for household use take place.
CM-MS-18	Pursue opportunities to acquire fee title, easement, and water rights from willing sellers.	**SFI** – *Anderson Creek Watershed Project* provided for the maintenance and improvement of coho and steelhead spawning and rearing habitat on Anderson Creek through the fee title and conservation easement acquisition of the McMurray property, and the purchase of 190 acres of land from Barnum Timber to be held in fee-title by SFI and managed by the Upper Mattole River and Forest Cooperative. SFI funds have been used in 2009 to collaborate with DFG and Save-the-Redwoods League in the pursuit of acquiring fee title to property in the North Fork of Lost River for the purpose of water conservation and water recharge projects. Initial site visits to this critical coho habitat have been completed with DFG, Save-the-Redwoods, SFI staff and participating landowners to assess the water conservation and recharge value of the property. The vision for this property includes development of a collaborative team to design and implement groundwater recharge projects that will generate summer streamflow required to restore some of the best coho juvenile summer habitat in the Mattole mainstem.
CM-MS-19	Plant trees appropriate to the location in riparian areas where conditions are suitable.	**MRC** – Planted approximately 8,200 seedlings, primarily Douglas-fir, in riparian areas in Thompson, Yew, McNasty, and Ancestor Creeks, and Lost River.
CM-MS-20	Supplement on-going efforts to provide short-term and long-term benefits to coho salmon by restoring LWD and shade.	**MSG** – Completed over 42 LWD structures in the southern subbasin since 2004, in Thompson and Upper Mill Creeks. Implementation is planned and funded in 2010 and 2011 in Thompson, Bridge, and Ancestor Creeks.

CM-MS-22	Treat high priority barriers to coho salmon passage.	**MRC** – Two barriers were removed on Thompson Creek, three barriers were removed on Ravasoni Creek, and two barriers were removed on Van Auken Creek.

Task ID (CDFG 2004)	Description	Work Completed by MRRP Groups Through 2009
8.1.12.2 Western Subbasin Mattole River HAS		
CM-MW-01	Assess current levels of LWD, determine amount necessary for improved flushing, pooling and habitat conditions for coho salmon, facilitate immediate placement and develop a plan for long-term recruitment.	**MRC –** Tallied wood totals in 20 stream reaches in the Western Subbasin in 2007 using CDFG "core attributes" protocols.
CM-MW-02	Facilitate immediate placement of LWD in areas where lacking.	**MSG** – Completed complex LWD structure at the mouth of Stansberry Creek, constructed 4 LWD structures in Squaw Creek in 2006 under funding provided by DFG, and constructed 7 complex LWD structures, as well as annual small woody debris shade and cover structures in the Mattole estuary.
CM-MW-03	Develop and implement a plan for long-term recruitment of LWD.	**MRC** – Completed 4.3 acres of riparian silvicultural treatments along Honeydew, Bear and South Fork Bear Creeks designed to speed development of mature riparian canopy and increase long-term recruitment of LWD.
CM-MW-04	Cooperate in establishing monitoring stations at appropriate locations (e.g., Squaw, Honeydew, and Bear creeks) to monitor in-channel sediment and track aggraded reaches in the lower basin and in the lower reaches of major tributaries.	**MRC –** Completed channel monitoring of 20 stream reaches in the Western Subbasin in 2007 using CDFG "core attributes" protocols. Conducted winter-time monitoring of turbidity at five tributaries since the fall of 2008.
CM-MW- **05**	Support the assessment, prioritization, and treatment of sources of excess sediment.	**MRC** – A sediment assessment in the Bear Creek watershed identified 100 sites for treatment; treated sites between 2006 and 2010 with a total sediment savings of 47,560 cubic yards. A sediment assessment in the Honeydew Creek subshed will be completed in 2010, and thus far has identified 200,000 cubic yards of treatable sediment.

Appendix C
Summary of Work Completed by MRRP Groups to Address Tasks in *Recovery Strategy for California Coho Salmon* (CDFG 2004)

CM-MW-06	Encourage the monitoring of summer water and air temperatures using Department-accepted protocols. Continue temperature monitoring efforts in Stansberry, Mill (RM 2.8) Clear, Squaw, Woods, Honeydew, Bear, North Fork Bear, South Fork Bear, Little Finley, Big Finley, and Nooning creeks, and expand efforts into other subbasin tributaries.	**MSG** – Ongoing summertime water and air temperature monitoring program in conjunction with salmonid presence-absence surveys in the mainstem and major tributaries since 1995. Monitored temperature in many DFG priority Western Subbasin tributaries during that time. Since 2000, these have included Stansberry Creek, Mill Creek, Clear Creek, Squaw Creek, Woods Creek, Honeydew Creek and several tributaries, Bear Creek, North Fork Bear Creek, South Fork Bear Creek, and Big Finley Creek.
CM-MW-09	Assess and prioritize the actions needed for restoration and enhancement of riparian habitat.	**MRC** – Completed riparian assessments and planned treatments in Big Finley, Little Finley, South Fork Bear, Bear, Bear Trap, Honeydew, Granny, and Woods Creeks, Cook Gulch, and along the mainstem Mattole.
CM-MW-10	Implement the prioritized actions needed for restoration and enhancement of riparian habitat.	**MRC** – Planted 124,970 trees in riparian areas in the western subbasin, in Bear, Big Finley, and Honeydew Creeks, and along the mainstem Mattole.
CM-MW- 11	Recognize and support ongoing efforts of landowners, the BLM, and other to improve habitat conditions for coho salmon.	**MSG** – Provided numerous consultations with local residents as requested by landowners and other restoration groups. Work closely with the BLM to ensure annual salmonid population and habitat monitoring occurs throughout the watershed. Reports available to the public via MSG website, and are provided to many agencies, including DFG, NMFS, USFWS, among others, in addition to local landowners, in order to foster improved salmonid habitat stewardship.
CM-MW-13	Develop a public education program to raise awareness of the habitat needs of coho salmon and how the community, especially landowners, can improve coho salmon habitat.	**MSG** – Worked closely with SFI in the preparation of materials on water storage and conservation and its impact on coho salmon as well as other aquatic species. Annual education in the local community provided by MSG AmeriCorps members, which focuses on the salmonid life cycle and habitat needs. Semi-annual distribution of newsletter to recipients throughout the watershed. The newsletter includes status updates from MSG projects in addition to salmonid habitat information. **SFI** – While our education program is focused on the Southern Subbasin, recommendations and outreach is extended to the entire Mattole watershed through newspaper and radio public service announcements, newsletters and other publications, and SFI website updates. **MRC** – Semi-annual newsletter is distributed to all watershed residents. The Mattole Ecological Education Program works with all watershed schoolchildren every year.

CM-MW-15	Develop programs to support continued land-use patterns and discourage conversions and subdivisions.	**MRC** – Currently developing alternative economic opportunities for landowners intended to decrease subdivision threat, such as the Mattole PTEIR.
CM-MW-18	Treat high priority barriers to coho salmon passage.	**MRC** – Three fish passage barriers were removed on South Fork Bear Creek in 2008.

Task ID (CDFG 2004)	Description	Work Completed by MRRP Groups Through 2009
8.1.12.3 Northern Subbasin Mattole River HAS		
CM-MN-01	Encourage tree planting and other vegetation management to improve canopy cover, especially in Conklin, Oil, Green Ridge, Devils, and Rattlesnake creeks.	**MRC** – Conducted riparian assessments on Devils, Oil, Rattlesnake, East Mill, McGinnis, and Conklin Creeks and the Upper North Fork of the Mattole. Planted over 5,000 riparian trees on Lower North Fork and East Mill Creek.
CM-MN-02	Encourage cooperative efforts for treatment of stream-bank erosion sites to reduce sediment yield to streams, especially in Sulphur, Conklin, and Oil creeks and the lower reaches of the North Fork Mattole River.	**MRC** – Through the Petrolia Area Sediment Reduction Project and Ranchlands Water Quality Project, approximately 15 streambank erosion sites will be treated in the northern subbasin.
CM-MN-04	Assess and prioritize sources of excess sediment.	**MRC** – Sediment Assessments have been completed in the Petrolia, and Upper North Fork project areas, as well as on other Ranchlands in this subbasin. These assessments have identified 796,840 cubic yards of treatable sediment.
CM-MN-05	Treat sources of excess sediment.	**MRC** – 20,805 cubic yards of sediment has been stabilized in the Petrolia project area in projects completed to date.
CM-MN-07	Conduct an inventory and prioritize for treatment barriers to coho salmon migration other than county culverts.	**MSG** – Identified, leveraged funding, and implemented the removal of a 14-ft dam blocking all fish passage in a fork of East Mill Creek, northern subbasin. Removed and stabilized the accumulated sediment behind the dam and placed rock and wood structures for fish habitat in the resulting stream channel. Barrier removal reopened approximately one half-mile of coho salmon habitat.
CM-MN-8	Treat high priority barriers to coho salmon passage.	**See above.**

Task ID (CDFG 2004)	Description	Work Completed by MRRP Groups Through 2009
8.1.12.4 Eastern Subbasin Mattole River HAS		
CM-ME-01	Continue to conduct and implement road and erosion assessments, especially in Middle, Westlund, Gilham, Sholes, Blue Slide, and Fire creeks.	**MRC** – Sediment assessments have been completed in 90% of the subsheds in the eastern subbasin with over 700 sediment sources identified. Approximately 450 road sites and 55 streambank sites have been treated. The total sediment savings from these sites is approximately 280,000 cubic yards. Additional work was completed 2010.
CM-ME-03	Encourage tree planting and other vegetation management to improve canopy cover, especially in Dry and Blue Slide creeks.	**MRC** – Planted over 80,000 seedlings in the eastern subbasin since 2002, in Dry, Fourmile, Middle, Westlund, Sholes, Mattole Canyon, Blue Slide, and Wolf Creeks.
CM-ME-04	Encourage cooperation at stream-bank erosion sites to reduce sediment yield to streams, especially in Middle, Westlund, Gilham, North Fork Fourmile, Sholes, Harrow, Little Grindstone, Grindstone, Eubanks, and McKee Creeks.	**MRC** – 55 streambank sites have been treated in the eastern subbasin preventing approximately 180,000 cubic yards of sediment from entering watercourses.